ARGUMENT STRUCTURE IN SPECIFIC LANGUAGE IMPAIRMENT: FROM THEORY TO THERAPY

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ABSTRACT

This thesis is in two parts: the first focuses on theories of SLI and the development of argument structure while the second focuses on intervention.

Chapter 1 reviews experimental findings and theories of SLI and finds that while some areas of language are well-researched, others (including argument structure) have received relatively little attention. Chapter 2 reviews the literature regarding the development of argument structure and concludes that studies of *typical development* have not investigated use of alternations and omissions of obligatory arguments, whereas studies of *SLI* have little focus on alternations or overgeneralisations.

Chapters 4 and 5 therefore consider the performance of typically developing children and children with SLI on all these areas. I find typically developing children differ from adults in their use of the causative alternation and overgeneralisation of the locative alternation. The children with SLI have difficulties with argument structure, avoiding the ditransitive form of the dative alternation and making more errors with change of state verbs and omission of arguments.

A secondary focus (Chapter 6) is on the influence of phonological complexity and length (measured by a non-word repetition test) on the language abilities of children with SLI. The results show a bimodal split where half the children with SLI show normal abilities and half have significant difficulties. Chapter 7 discusses the implications of the experimental findings for theories of SLI.

Part 2 reviews intervention studies for SLI (Chapter 8) and presents an intervention study focusing on argument structure (Chapter 9). 27 secondary-aged children with SLI are randomly assigned to three groups, one control and two target therapies focusing on semantics vs constructions. Both target groups show significant progress. Thus, this thesis shows that detailed investigations of the nature of the deficit in SLI can lead to successful interventions even for children with severe, persistent difficulties.

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PART 1

ARGUMENT STRUCTURE IN SPECIFIC LANGUAGE IMPAIRMENT:

THEORY

CHAPTER 1 SPECIFIC LANGUAGE IMPAIRMENT

1.1 Overview of the chapter and thesis

Approximately 7% of children are estimated to have a specific language impairment (Leonard, 1998; Tomblin, Records, Buckwalter, Zhang, Smith & O'Brien, 1997). This can have serious long-term effects on their education, future careers and relationships (Howlin, Mawhood & Rutter, 2000; Clegg, Hollis, Mawhood & Rutter, 2005). Reducing these adverse effects is the primary goal of clinicians working with children with SLI and it is therefore vital that they use effective interventions. In order for clinicians to design and refine interventions, they need to know the areas of strength and weakness in SLI and the underlying cause(s) of the children's difficulties. They can then design interventions which either tackle the underlying cause(s) directly or use the children's strengths to circumvent their core difficulties and improve their language functioning.

However, clinicians are hampered by the lack of research consensus in this area. The research community does not yet agree on either the nature of the difficulties experienced by children with SLI or why they experience difficulties and hence how to improve their language functioning. Much of this disagreement stems from the fact that different research groups have identified children with SLI using different criteria. Most researchers recognise that the behavioural manifestations of SLI are heterogeneous. For this reason, some have proposed subgroups (e.g., Rapin & Allen, 1987), a few researchers restrict their investigations to tightly defined subgroups (e.g., van der Lely) whereas others study a more diverse group of children (e.g., Conti-Ramsden). The study of subgroups has the advantage that the children's difficulties are more homogeneous and it is therefore easier to draw theoretical conclusions about the nature of their deficits. However, it is unclear whether the proposed subgroups represent qualitatively different groups of children, whether they overlap or whether the children fall on a continuum.

With regard to the language symptoms manifested by children with SLI, a degree of consensus has been reached among many investigators on the existence of difficulties in some areas of language (e.g., morphology). However, some areas (e.g., syntax and argument structure) have been studied by a much smaller group of investigators and their results do not always agree. In other areas there is reasonable consensus that as a group, children with SLI have difficulties with particular tasks (e.g., non-word repetition), but little agreement as to the underlying reason for this, or even what the tasks tap. This lack of consensus as to the behavioural manifestations of SLI inevitably leads to a wide variety of theoretical explanations, but given the limited data in some areas it is difficult to evaluate the relative merits of these theories.

Theories of SLI fall into two main 'camps' regarding the linguistic deficit in SLI: some regard it as a primary deficit whereas some regard it as secondary to other underlying cognitive difficulties. The majority of theories of SLI propose one underlying cause. Although this would be the most parsimonious explanation, it may not in fact be the case that one underlying cause can account for all the difficulties of all children with SLI. Multiple factors may be involved, which when they co-occur, lead to a more severe degree of impairment.

One consequence of the lack of consensus as to the nature and causes of SLI is that the way forward for intervention is unclear. Very little research has been published regarding intervention for children with SLI, particularly with school-aged children (Law, Garrett & Nye, 2003). This is partly because it is difficult to know on which theory to base an intervention. The various theories of SLI have very different implications for the types of intervention which may be effective. Indeed intervention could be used as a way of testing these theories. Unfortunately however, the majority of those intervention studies which have been published are not grounded in any particular theory and do not evaluate the theories of SLI in the light of their outcomes.

This thesis aims to extend the data regarding the difficulties found in children with SLI. In particular, it will investigate argument structure, an area of language which has previously received little attention in the study of SLI. It reports on detailed investigations of production and judgement of argument structure in both children with SLI and typically developing controls. This thesis also investigates further the difficulties frequently reported with non-word repetition, including the links between performance on this task and other areas of language. The possible factors underlying poor performance on non-word repetition are also investigated, in particular the impact of length and phonological complexity. The findings of these investigations then provide a basis for an intervention study which investigates the effectiveness of two different types of intervention for improving argument structure performance in secondary school aged children with SLI.

1.2 Identification of children with Specific Language Impairment

The primary criterion for diagnosing SLI is that the child has poorer language abilities than would be expected for his/her age. However, a child could perform poorly on a language test for a variety of reasons. Some children will naturally fall towards the bottom of the normal distribution but may have no specific deficit in language; their language difficulties could be part of more general learning difficulties. They may have had limited linguistic input either for environmental reasons (Curtiss, 1977) or as a result of limited hearing levels (Bench & Bamford, 1979) or because specific medical factors have directly affected the brain (Landau & Kleffner, 1957). Therefore, SLI has historically been diagnosed only if such factors are not present.

The factors most commonly used as exclusionary criteria are hearing loss, low nonverbal IQ, neurological dysfunction and emotional or social difficulties (either internal to the child, as in autism, or as a result of their environment). Other exclusionary criteria include: recent episodes of otitis media with effusion ('glue ear'), oral structural anomalies and poor oral motor function. However, if SLI is a genetic disorder, as is now widely believed, there is no theoretical reason why a child should not have SLI *and* any one of these other features e.g., poor oral motor function (Gopnik & Crago, 1991), low non-verbal IQ (Bishop, North & Donlan, 1995), or a hearing impairment (Ebbels, 2000). The use of exclusionary criteria could result in the identification of only a subgroup of children with SLI. A balance has to be struck between inclusion of false positives (children who do not have SLI) and exclusion of false negatives (children who do have SLI but also have some other co-occurring difficulties). The relative weighting of these factors will vary according to the purpose of diagnosis. Some basic theoretical research requires 'pure' cases of SLI, as it aims to use SLI as a window on the fundamental mechanisms of language and thus all possible confounding factors in the data need to be ruled out. In clinical practice, on the other hand, a low false negative rate is desirable in order to ensure that all children who have SLI are identified and receive the most appropriate support available, regardless of whether they also have other difficulties. In the latter case, diagnosis by clinical markers would be preferable to diagnosis by exclusion.

One of the more controversial exclusionary criteria is that of non-verbal (or performance) IQ. Rice et al. (2004) found that low performance IQ cannot in itself explain language difficulties as children (aged 6 yrs) with low performance IQ showed similar abilities on a test of verb tenses to control children with normal IQs. Also, these children scored higher than children with SLI (with normal performance IQs) on the verb tense test. Several researchers have also begun to question whether those children who have language impairments in the presence of low performance IQs are qualitatively different from those with higher IQs as far as their language difficulty is concerned (Bishop, 1994b). Such children may have the same underlying deficits in language but just happen to fall at the lower end of the normal performance IQ distribution. The performance IQ cut-off is therefore beginning to be relaxed in research with a more clinical focus (Botting & Conti-Ramsden, 2001; Knox & Conti-Ramsden, 2003; Conti-Ramsden & Hesketh, 2003). Clinicians rarely exclude children on the basis of performance IQ as there is little evidence that children with lower IQs respond in different ways to intervention (Notari, Cole & Mills, 1992; Cole, Schwartz, Notari, Dale & Mills, 1995; Fey, Long & Cleave, 2004) or that performance IQ accounts for any variation in outcome once linguistic factors have been taken into account (Botting, Faragher, Simkin, Knox & Conti-Ramsden, 2001). Further evidence which encourages the relaxation of performance IQ criteria, particularly for older children with SLI is provided by the findings that performance IQ decreases with age in some children with SLI (Cole et al., 1995; Mawhood, Howlin & Rutter, 2000; Hansson, Forsberg, Lofqvist, Maki-Torkko & Sahlen, 2004). Based on such evidence, some researchers have proposed that we should define SLI by identifiable characteristics instead of ruling out what is *not* an SLI profile (Conti-Ramsden, Botting & Faragher, 2001). Therefore several researchers now aim to identify a specific set of clinical (or risk) markers that characterise the language or processing abilities of SLI children, regardless of performance IQ and indeed other traditional exclusionary criteria.

The clinical (or risk) markers for SLI which have been proposed to date are: finite verb morphology (Rice & Wexler, 1996; Bedore & Leonard, 1998; Leonard, Miller & Gerber, 1999), non-word repetition (Kamhi & Catts, 1986; Bishop, North & Donlan, 1996; Bishop, Bishop, Bright, James, Delaney & Tallal, 1999a; Conti-Ramsden & Hesketh, 2003; Conti-Ramsden, 2003) and sentence repetition (Kamhi & Catts, 1986; Conti-Ramsden et al., 2001). Bedore and Leonard (1998) found a verb morphology composite correctly identified all children with typical language development, and 85% of children with SLI. They therefore concluded that verb morphology is a useful starting point for the identification of SLI. The reliability of non-word repetition as a predictor of language status has been tested through the use of 'likelihood ratios' (Dollaghan & Campbell, 1998; Ellis Weismer, Tomblin, Zhang, Buckwalter, Chynoweth & Jones, 2000), which reveal how many times more likely it is that a particular score on a test comes from a child with SLI versus a control child.

From this it is possible to calculate the percentage chance of correct identification. Dollaghan and Campbell (1998) found that certain levels of performance on their non-word repetition test were very powerful predictors of language status: on total percentage of consonants correct, scores of <70 had a 95% chance of coming from an child with SLI whereas a score of >81 only had a 3% chance of coming from a child with SLI. Ellis Weismer et al. (2000) also found non-word repetition to be a useful index; however, it was not sufficient on its own for ruling a language impairment in or out. These findings indicate that non-word repetition cannot be used in isolation to identify a child with SLI, possibly because it is neither necessary nor sufficient to cause SLI, but together with other markers could indicate an increased risk of a child having SLI. Future research needs to validate the use of such markers and also to indicate the levels of performance on each marker (at different ages), which indicate an increased risk of SLI.

1.3 The heterogeneity of SLI and proposed subgroups

An inherent difficulty in the study of children with SLI is the heterogeneity of their linguistic and non-linguistic symptoms. Two possible approaches can be used in this situation. The first studies a wide range of children with SLI, looks for patterns of impairment within the group and identifies possible clusters of children. The alternative approach studies tightly defined subgroups and then establishes later whether their patterns of difficulties can be generalised to other children outside the subgroup.

One of the best-known subgroup classifications is that of Rapin and Allen (1987). They describe 6 subgroups, which they claim are appropriate for both language and autistic disorders. These were based on clinical observations and not validated statistically. These subgroups are often used clinically but there is considerable overlap in the symptoms of the various subgroups. Figure 1.1 is based on Rapin and Allen's description of the symptoms involved in each subtype. The labels in black show the symptoms; those in colour are the names of the various subgroups. Those symptoms found in a subgroup are circled in the same colour as the name of the subgroup (the distance between symptoms does not have any particular significance). Note that this diagram only shows the presence or absence of a symptom, not severity and therefore there may be further differences (in severity) between subgroups which are not captured.

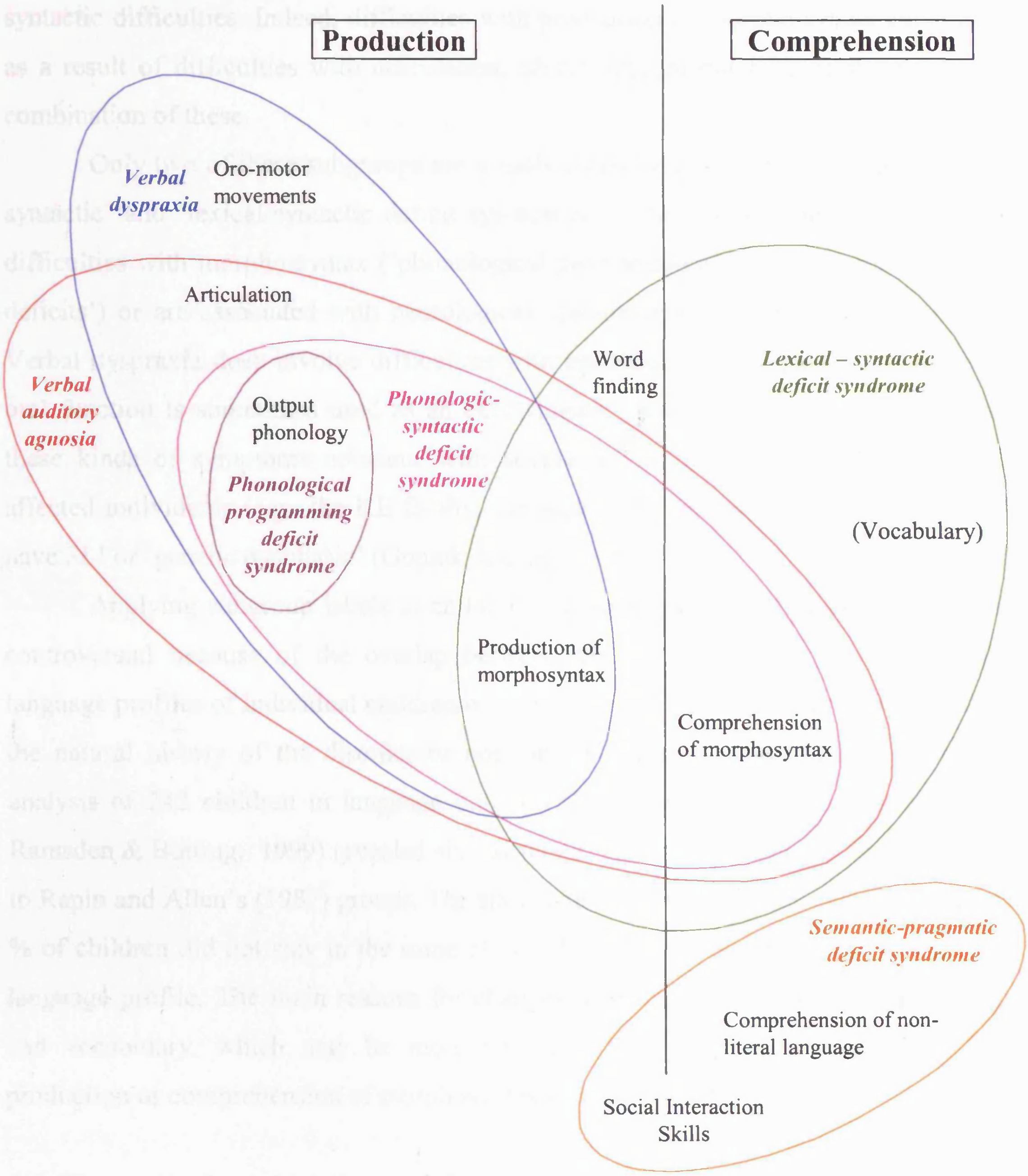


Figure 1.1: SLI subgroups based on Rapin and Allen (1987)

Figure 1.1 shows the high degree of overlap of the various 'subgroups'. Some of the subgroups are entirely contained within other subgroups showing that some symptoms can occur in isolation (e.g., output phonology) but can also co-occur with other symptoms (for example in conjunction with difficulties with morpho-syntax). This raises the possibility that there are in fact separate disorders which can occur independently but may co-occur. Figure 1.1 shows only the surface symptoms, but the same symptom may arise for a variety of reasons. For example, difficulties with the production of morpho-syntax may arise from difficulties articulating consonant clusters in children with 'verbal dyspraxia', whereas in children with a 'phonologic– or lexical-syntactic deficit syndrome' the same surface difficulties may be due to underlying syntactic difficulties. Indeed, difficulties with production of morpho-syntax could arise as a result of difficulties with articulation, phonology, morphology or syntax, or any combination of these.

Only two of these subgroups are usually considered to be SLI (the 'phonologic-syntactic' and 'lexical-syntactic deficit syndromes'). The others either do not involve difficulties with morpho-syntax ('phonological programming' and 'semantic-pragmatic deficits') or are associated with neurological impairments ('verbal auditory agnosia'). Verbal dyspraxia does involve difficulties with production of morpho-syntax but poor oral function is sometimes used as an exclusionary criterion for SLI. However, when these kinds of symptoms co-occur with severe difficulties of language production, affected individuals (e.g., the KE family, see section 1.5 below) may be considered to have SLI or 'genetic dysphasia' (Gopnik & Crago, 1991).

Applying subgroup labels to children or attempting to study these subgroups is controversial because of the overlap between the subgroups and also because the language profiles of individual children may change with age. This may be as a result of the natural history of the disorder or possibly as a result of intervention. A cluster analysis of 242 children in language units on two occasions, one year apart (Conti-Ramsden & Botting, 1999) revealed six clusters of children which were broadly similar to Rapin and Allen's (1987) groups. The six clusters were stable over time, however, 45 % of children did not stay in the same cluster due to genuine clinical changes in their language profile. The main reasons for changes of group, were changes in phonology and vocabulary, which may be more amenable to change with intervention than production or comprehension of morphosyntax (Law et al., 2003).

1.4 Theoretical explanations of SLI

Theoretical explanations of SLI fall into two main 'camps' and these reflect the more wide-ranging debate about the nature of language development generally. This debate hinges on whether language is learned using general cognitive abilities: the developmental perspective (Karmiloff-Smith, 1998; Tomasello, 2000b; Thomas & Karmiloff-Smith, 2003) or specialised cognitive mechanisms which unfold under genetic control: the nativist perspective, (Fodor, 1983; Chomsky, 1986; Pinker, 1994b; 2002). The two main groups of theories of SLI reflect the two sides of this general debate and can be classed as linguistic (or domain specific) versus processing (or domain general) theories. The linguistic theories claim that children with SLI are impaired in specific areas of language. The differences between the theories lie in the precise areas of language or mechanisms which are assumed to be impaired, for example: late maturation of the part of morpho-syntax which enables children to mark tense (Rice, Wexler & Cleave, 1995), the lack of computations required to form non-local dependency relations, which affects passives, 'wh' questions and binding (van der Lely, 1998), or an impairment in the 'optional non-interpretable phi-features of verbs' affecting the ability to mark agreement (Clahsen, Bartke & Gollner, 1997). Conversely, processing theories claim that the cause of the difficulties found in SLI do not stem from the language system itself, but from other mechanisms which are used to learn language. These theories range from those which claim the difficulty is general in nature, for example slow processing (Bishop, 1994a) or limited processing capacity (Leonard, 1998) to theories which hypothesise specific deficits, for example with phonological short term memory (Gathercole & Baddeley, 1990) or processing rapid auditory transitions (Tallal, Stark & Mellits, 1985).

One reason for such variation in explanations is that the theories do not all attempt to account for the same set of symptoms, as there is disagreement regarding the actual areas of deficit in SLI. Therefore, in order to begin to evaluate the various theories of SLI, we first need to consider the difficulties children with SLI have in both linguistic and other areas.

1.5 Evaluating the data on difficulties in SLI

In order to make sense of the (often conflicting) data regarding the difficulties in SLI, we need to bear two key questions in mind: who are the children with SLI and who are they being compared with? We need to consider the age of the children (both SLI and controls), whether the children with SLI belong to a particular subgroup or constitute a more general group, the nature of the control children and how they have been matched to the SLI group.

Many potentially conflicting findings may arise as a result of differing ages of the children in the studies as most areas of language or processing would be expected to improve with age. Comparisons of findings therefore need to consider this factor and the possible confounding effects of studying children of different ages. Those studies using young children run a greater risk of including children who merely have delayed language and not SLI. It is also not possible to study many areas of language until the children are producing utterances of a certain length. In contrast, a disadvantage of using older children is that they may no longer show a (possibly causal) deficit which was present when they were younger and also they may have developed (or been taught) compensatory strategies to carry out tasks, thus making it difficult to establish their core strengths and weaknesses. Longtitudinal studies would be ideal in order to follow the developmental course of the disorder but the majority of researchers do not have the resources to carry out such studies, so we have to rely on piecing together the results of separate cross-sectional studies.

Two research groups in particular have studied specific subgroups of children with SLI. Gopnik and colleagues have studied the KE family; a large multigenerational family approximately half of whom have a language disorder. The studies of this family reported in this chapter involve affected family members whose ages range from 10 to 77 years. Recently, the gene which appears to lie at the root of their difficulties (FOXP2 on Chromosome 7) has been identified (Lai, Fisher, Hurst, Vargha-Khadem & Monaco, 2001). This gene co-segregates with the speech and language phenotype and has an autosomal dominant inheritance pattern. However, it seems that this family and others with the same mutation in FOXP2 constitute a separate subgroup of people with language disorders, as the same mutation has not been found in children with the common form of SLI (SLI Consortium, 2002). The genetic and phenotypic differences (e.g., oral motor difficulties) between the KE family and other children with SLI mean that it is not clear that conclusions drawn about the underlying linguistic or processing nature of the difficulties in this family can be generalized to the rest of the SLI population.

The subgroup studied by van der Lely and colleagues is the Grammatical (G)-SLI subgroup. This group displays particular difficulties in the grammatical system with relatively intact abilities in other areas and are all over the age of 9 years. However, the existence of this pure subgroup of children with G-SLI has been questioned by other researchers (Bishop, Bright, James, Bishop & Van der Lely, 2000; Norbury, Bishop & Briscoe, 2002) who found that although many children with SLI show several of the features of G-SLI, very few meet *all* the criteria *and* are specific in their impairment (many also had lower IQs and other language difficulties). Therefore it is unclear whether the children in this subgroup are qualitatively different from other children with SLI, or whether they show the same difficulties but in a more 'pure' form. It is possible that many other children with SLI have the same types of difficulties, but also have additional difficulties in other areas of language and processing which co-occur with their core grammatical difficulties.

Another important factor to consider when comparing studies of SLI is the use of control groups. Some studies do not use control groups, hence it is difficult to know whether the difficulties found in children with SLI in the particular area under investigation are greater than would be expected for their chronological age, or their general language ability. Many studies compare children with SLI either to chronological age or language controls or both. The different control groups answer different questions. Chronological age matched controls are used to establish whether the children with SLI have more difficulty with the area under investigation than would be expected for their age. This is necessary for establishing first whether they do in fact have a clinical difficulty with the particular area. It is important to consider not only the group data but also individual data in this respect. Several theories propose that difficulties in particular areas of language or processing are defining of language difficulties. It is therefore important to establish whether *all* children with SLI have difficulties in that area or whether it is only the group mean which falls below normal levels. If some children with SLI perform within the normal range for their age on a particular area, despite having a language deficit, the hypothesis that that area is *the* underlying cause of SLI is weakened.

Language-matched controls have a different purpose; they are used to establish whether the children with SLI have more difficulties in particular areas than would be predicted from their general language abilities. This can be useful in evaluating possible cause and effect relations. For example, if children with SLI omit more copulas than children of the same age, it could be that this is due to their generally reduced length of utterance (which could arise for a variety of reasons). However, if they omit more copulas than children with similar mean length of utterances (who are younger) it is more likely that they have a particular difficulty with some feature of copulas rather than other more general factors. The difficulty with language-matched controls is that the interpretation of the findings depends on the test or measure on which they have been matched. Non-significant differences between the language matched groups and children with SLI implies that the area being studied is closely related to the area used to match them. If there is a difference, the implication is that the two areas are less closely related.

Other studies have compared the performance of children with SLI with another clinical group who do not have the same level of language difficulties, for example those with reading difficulties (Kamhi & Catts, 1986; Kamhi, Catts, Mauer, Apel & Gentry, 1988) or mild to moderate hearing impairments (Briscoe, Bishop & Norbury, 2001; Norbury, Bishop & Briscoe, 2001; 2002). These designs can be used to test particular hypotheses regarding the underlying cause of SLI. If the two groups show equivalent performance on a proposed core deficit (for example, phonology) but the comparison group do not have language difficulties, it cannot be claimed that the proposed deficit (on its own) causes language impairments.

Thus, while individual comparisons with age-matched controls can be used to establish whether a proposed deficit is *necessary* to cause a language impairment, comparisons with other clinical groups can be used to establish whether it is *sufficient*. If the proposed deficit can be found in other populations who do not have language impairments, the deficit cannot be sufficient to cause a language impairment.

Theoretical explanations of SLI need to be able to account both for general language difficulties compared to age controls and also those areas which are particularly impaired relative to language-matched controls. The following sections detail the linguistic and non-linguistic difficulties found in children with SLI compared to both age and language controls before describing some of the proposed explanations of SLI and evaluating them in the light of these data.

1.6 Linguistic difficulties in SLI

1.6.1 Morphology

Difficulties with morphology, particularly verb morphology, are widely reported and are also notoriously persistent. Table 1.1 summarises the findings of studies investigating particular areas of morphology in children with SLI. The table shows good agreement in some areas and less agreement in others. With regard to tense markers, there is almost unanimous agreement that (English) children with SLI omit regular past tense *–ed,* and irregular past tenses. However, compared to controls, they seem to have fewer difficulties producing irregular past tenses, where they perform at the same level as their language-matched controls (Leonard, Bortolini, Caselli, McGregor & Sabbadini, 1992a; Leonard, Eyer, Bedore & Grela, 1997). Van der Lely and Ullman's (2001) study throws further light on this finding as the children with G-SLI in their study performed worse than children matched on vocabulary but not those matched on morphology. This indicates that their difficulties with irregular past tenses are more dependent on their morphological than lexical abilities. Their relatively greater difficulties compared to controls on the regular past tense could be due to the fact that children with SLI do not show the usual advantage of regular over irregular past tense (Gopnik & Crago, 1991; van der Lely & Ullman, 1996). They also show a frequency effect for regular as well as irregular past tense verbs (van der Lely & Ullman, 2001; Oetting & Horohov, 1997; Ullman & Gopnik, 1999) which has been interpreted as showing that they preferentially store both regular and irregular past tenses in their lexicons. In addition, they produce few over-regularisations compared to controls, leading to proposals that they have not formed morphological paradigms for the past tense (Gopnik & Crago, 1991; Leonard et al., 1992a).

The overwhelming majority of past tense errors are omissions. Virtually no commission errors (e.g., use of the past tense in a present tense context) have been reported. A similar pattern has been found for judgement where children with G-SLI accept correct forms but do not reliably reject incorrect forms (van der Lely & Ullman, 1996). Very few studies have reported intact abilities with tense; the exception is Clahsen et al. (1997) who claim children with SLI do not have real difficulties with tense, as they report only 10-15% errors. However, given that these children are 10-13 years old, and normally developing children make very few errors after the age of 5, this is probably a significant deficit.

As regards agreement, the majority of studies in Table 1.1 report English children with SLI omit the 3rd person singular *–s* marker and also forms of "be". The omission of these morphemes could be interpreted as a deficit in tense marking (Rice et al., 1995) but this view is challenged by cross-linguistic evidence from Italian and German, showing inflection errors usually consist of an incorrect substitution error rather than a non-finite form (Leonard et al., 1992a; Clahsen et al., 1997; Bortolini, Caselli & Leonard, 1997). In English, present tense marking has no phonological content (except for third person), so it is impossible to tell if a child is using the non-finite form of the verb or has selected an incorrect tense-marked form. In English, it is only possible to make this distinction using the verb "be" where the non-finite form is not homophonic with a tense marked form. Indeed the only commission errors which are consistently reported for English speaking children with SLI are with this verb (van der Lely, 1997; Leonard et al., 1997; Leonard, Deevy, Miller, Charest, Kurtz & Rauf, 2003). Interestingly, the substituted form is usually use of the 3rd person singular form ('is' or 'was') for the 3rd person plural form ('are' or 'were'), the same substitution pattern as that reported in Italian (Leonard et al., 1992a; Bortolini et al., 1997).

Table 1.1: Difficulties with morphology reported in the literature, CA=chronological age controls, LA=language age controls.

Difficulty with.....?	Study	Language	SLI age (N)	Control matches (N)	Findings
Use of regular past (*-ed*)	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	LA (40), CA (45)	SLI < LA & CA
	(Rice et al., 1995)	English	4;7-5;8 (18)	CA (22), LA (20)	SLI < LA < CA
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	SLI < LA
	(Oetting & Horohov, 1997)	English	6 yrs (11)	LA (11), CA (11)	SLI < LA & CA
	"	"	"	"	/ɪd/: SLI = LA, SLI< CA
	(van der Lely & Ullman, 2001)	English	9;3-12;10 (12)	Morph (12), vocab (24)	G-SLI < LA controls
	(Marchman et al., 1999)	English	6;1-12;0 (31)	CA (31)	SLI<CA (especially verbs requiring /ɪd/)
	(Gopnik & Crago, 1991)	English	16-74yrs (6)	family 8-17 years (6)	KE < controls
	(Ullman & Gopnik, 1999)	English	10-77 yrs (7)	family 16-57 yrs (3)	5/7 had difficulties (SLI < controls)
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	10 made omission errors
	(Clahsen et al., 1997)	English	10;0-13;1 (9)	none	76-89% correct (reg + irreg)
	"	German	5;8-7;11 (6)	none	99% correct (reg + irreg)
Use of irregular past	(Marchman et al., 1999)	English	6;1-12;0 (31)	CA (31)	SLI<CA
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10), CA (10)	SLI = LA
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	SLI = LA < CA
	(van der Lely & Ullman, 2001)	English	9;3-12;10 (12)	Morph (12), vocab (24)	G-SLI = morphology conts, G-SLI < vocab conts
	(Ullman & Gopnik, 1999)	English	10-77 yrs (7)	family 16-57 yrs (3)	KE < controls
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	All made omission errors
Over-regularisation errors	(Marchman et al., 1999)	English	6;1-12;0 (31)	CA (31)	SLI=CA
	(Oetting & Horohov, 1997)	English	6 yrs (11)	LA (11), CA (11)	SLI > LA & CA
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	SLI: 21.6% of errors, LA: 15.3%, CA: 81.9%
	(Gopnik & Crago, 1991)	English	16-74yrs (6)	family 8-17 years (6)	No over-regularisations
	(Ullman & Gopnik, 1999)	English	10-77 yrs (7)	family 16-57 yrs (3)	No over-regularisations
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	A few examples
Past tense used in present tense context?	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	No such errors
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	No such errors
	(Rice et al., 1995)	English	4;7-5;8 (18)	CA (22), LA (20)	No such errors
	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	CA (45), LA (40)	1/75 past tenses were in present tense context
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	None for regular past & "rare" for irregular past
Judgement of inflected past tense (correct forms)	(van der Lely & Ullman, 1996)	English	9;3-12;10 (12)	morph (12), vocab (24)	G-SLI = controls
Judgement of uninflected past tense (incorrect forms)	(van der Lely & Ullman, 1996)	English	9;3-12;10 (12)	morph (12), vocab (24)	G-SLI < controls

Table 1.1 (cont.)

Not usual advantage of reg over irreg past forms?	(Gopnik & Crago, 1991)	English	16-74yrs (6)	family 8-17 years (6)	KE: irregular > regular
	(van der Lely & Ullman, 2001)	English	9;3-12;10 (12)	morph (12), vocab (24)	SLI do not show regular advantage, controls do
	(Ullman & Gopnik, 1999)	English	10-77 yrs (5)	family 16-57 yrs (3)	1/5 KE: irregular>regular, 4/5: regular>irregular
Frequency effect for regular verbs?	(van der Lely & Ullman, 2001)	English	9;3-12;10 (12)	morph (12), vocab (24)	Frequency effect for SLI, not for controls
	(Oetting & Horohov, 1997)	English	6 yrs (11)	LA (11), CA (11)	Larger effect for SLI than LA
	(Ullman & Gopnik, 1999)	English	10-77 yrs (7)	family 16-57 yrs (3)	2/7 KE: Borderline effect, 3/7 & controls: no effect
Use of subject-verb agreement morphemes (3s for English)	(Rice et al., 1995)	English	4;7-5;8 (18)	CA (22), LA (20)	SLI < LA < CA
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	SLI < LA < CA
	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	CA (45), LA (40)	SLI < LA & CA
	(Leonard et al., 2003)	English	4;6-6;7 (15)	LA (15), CA (15)	SLI < LA = CA
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	SLI < LA
	(Rice & Oetting, 1993)	English	4;1-5;9 (50)	LA (58)	SLI < LA
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	Omitted in 5/18 examples
	(van der Lely, 1998)	English	10;3-14;5 (1)	none	20-64% correct
	(Clahsen et al., 1997)	English	10;0-13;1 (9)	none	35% correct
	"	German	5;8-7;11 (6)	none	64% correct
	(Leonard et al., 1992a)	Italian	4;0-6;0 (15)	LA (15), CA (15)	SLI = LA = CA
	(Bortolini et al., 1997)	Italian	4;1-7;0 (12)	LA (12), CA (12)	SLI = LA = CA
Use of incorrect form of verb in present tense	(Rice et al., 1995)	English	4;7-5;8 (18)	LA (20), CA (22)	no commission errors for 3s
	(Rice & Oetting, 1993)	English	4;1-5;9 (50)	LA (58)	no commission errors for 3s
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	8% commission errors for 3s (SLI = LA)
	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	CA (45), LA (40)	2% commission errors for 3s, but 89% with 'be'
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	no commission errors for 3s, but 89% with 'be'
	(Leonard et al., 2003)	English	4;6-6;7 (15)	LA (15), CA (15)	forms of "be": SLI < LA < CA
	(van der Lely, 1997)	English	10;3-12;2 (1)	none	no commission errors for 3s, but 50% with 'be'
	(Leonard et al., 1992a)	Italian	4;0-6;0 (15)	LA (15) and CA (15)	Use 3s for 3pl
	(Bortolini et al., 1997)	Italian	4;1-7;0 (12)	CA (12), LA (12)	Use 3s for 3pl
	(Clahsen et al., 1997)	German	5;8-7;11 (6)	none	90% use of incorrect forms
Use of obligatory "be"	(Rice et al., 1995)	English	4;7-5;8 (18)	CA (22), LA (20)	SLI < LA < CA
	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	CA (45), LA (40)	SLI < LA < CA
	(Leonard et al., 1997)	English	3;8-5;7 (10)	LA (9), CA (9)	SLI < LA < CA
	(Leonard et al., 2003)	English	4;6-6;7 (15)	CA (15), LA (15)	SLI < LA < CA
	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	SLI < LA
	(Bortolini et al., 1997)	Italian	4;1-7;0 (12)	LA (12), CA (12)	SLI = LA = CA
	(Clahsen, 1989)	German	3;2-9;6 (10)	none	High deletion rates

Table 1.1 (cont.)

Regular plural marking	(Leonard et al., 1992a)	English	3;8-5;7 (10)	LA (10) and CA (10)	SLI < LA
	(van der Lely & Christian, 2000)	English	10;4-18;0 (16)	LA (24), CA (12)	G-SLI = LA = CA
	(Oetting & Rice, 1993)	English	4:7-5;8 (18)	LA (18), CA (19)	SLI = LA < CA
	(Gopnik & Crago, 1991)	English	16-74yrs (6)	family 8-17 years (6)	KE < controls (nonsense words)
	(Rice & Oetting, 1993)	English	4;1-5;9 (50)	LA (58)	SLI < LA after quantifiers
	"	"	"	"	SLI = LA after determiners
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	SLI < LA = CA (worse with quantifier but poor on both)
	(Rice & Wexler, 1996)	English	4;4-5;8 (37)	LA (40), CA (45)	88% correct
	(Bishop, 1994a)	English	8;2-12;11 (12)	none	10/12 made omission errors, but >90% correct
	(Leonard et al., 1992a)	Italian	4;0-6;0 (15)	LA (15) and CA (15)	SLI = LA
	(Bortolini et al., 1997)	Italian	4;1-7;0 (12)	LA (12), CA (12)	SLI = LA < CA
Frequency effect for regular plurals	(Oetting & Rice, 1993)	English	4:7-5;8 (18)	LA (18), CA (19)	Frequency effect only for SLI
	(Leonard et al., 1997)	English	3;7-5;9 (9)	LA (9), CA (9)	Frequency effect only for SLI
Compounds produced with both regular and irregular plurals	(van der Lely & Christian, 2000)	English	10;4-18;0 (16)	LA (24), CA (12)	SLI use regular plural, controls don't
	(Oetting & Rice, 1993)	English	4:7-5;8 (18)	LA (18), CA (19)	Use of regular plural rare in all groups

The data regarding the use of plurals is much less clear-cut. Some studies have found very few errors on plurals (Bishop, 1994a; Rice & Wexler, 1996). Of those which compared performance with controls, two studies found children with SLI performed worse than language matched controls (Leonard et al., 1992a; Leonard et al., 1997) and two found they were worse only than age-matched controls (Oetting & Rice, 1993; Bortolini et al., 1997). The lack of consensus could be related to the finding that children with SLI are only worse than controls on plurals which follow quantifiers (Oetting & Rice, 1993). In parallel with the findings for verb morphology, a frequency effect has also been found for regular plurals (Oetting & Rice, 1993; Leonard et al., 1997) and some children with SLI have been shown to produce both regular and irregular plurals inside compounds. This could also indicate that children with SLI preferentially store regular plurals in the same way as regular past tenses (van der Lely & Christian, 2000).

1.6.2 Syntax

Far fewer studies have focused on syntax than morphology in children with SLI, although van der Lely and colleagues have carried out several, the later studies focusing on the G-SLI subgroup. They have particularly investigated comprehension of syntax and found children with SLI have difficulties understanding active (van der Lely & Dewart, 1986; van der Lely & Harris, 1990) and passive sentences (van der Lely & Harris, 1990; van der Lely, 1996), both forms of the dative alternation (discussed further in Chapter 2, section 2.3.3) (van der Lely & Harris, 1990), embedded phrases and clauses (van der Lely & Hennessey, 1999) and pronouns which rely on the use of binding principles (e.g., 'him' vs. 'himself'), although not those relying on semantic or lexical knowledge (e.g., 'him' vs. 'her') (van der Lely & Stollwerck, 1997). In contrast, Gopnik and Crago (1991) report that the affected members of the KE family have no difficulties with comprehension of passives or pronouns relying on binding principles. Similar difficulties to those reported by van der Lely and colleagues have been reported in the general SLI population for the comprehension of passives (Bishop, 1979; Precious & Conti-Ramsden, 1988; Ebbels & van der Lely, 2001; Norbury et al., 2001) and datives (Ebbels, van der Lely & Dockrell, 2002).

Some studies have considered the abilities of children with SLI to use syntax to 'bootstrap' into verb meanings but this will be discussed in Chapter 2 (section 2.3.2).

Van der Lely and colleagues also describe difficulties with expressive syntax. Children with G-SLI use few embedded or subordinate clauses (van der Lely, 1997) and they make errors when forming *wh*-questions, particularly object questions, producing for example double tense errors (e.g., "what did they drank?") and filling the gap left by the moved *wh*-word (e.g., "which one did he wear the coat?") (van der Lely & Battell, 2003). Similar difficulties with *wh*-questions have also been reported in the general SLI population: lack of auxiliary inversion (Menyuk, 1969; Connell, 1986; Leonard, 1995) and double tense errors (Ebbels & van der Lely, 2001).

1.6.3 Phonology

Children with SLI are frequently reported to have difficulties with expressive phonology (Gopnik & Crago, 1991), although only a few studies show this experimentally (e.g., Bortolini & Leonard, 2000). However such difficulties do not seem to occur in all sub-groups of SLI. For example the G-SLI subgroup have been reported to show few difficulties with known words (van der Lely, 1998) although they do have difficulties repeating non-words (Gallon, van der Lely & Harris, 2005, ms). Bortolini & Leonard (2000) showed phonological difficulties could be related to morphological difficulties; they found production of inflections involving consonants (past *–ed*, plural *–s*, genitive *'s*, third person singular *–s*) correlated with final consonant reduction in monomorphemic words in a group of English speaking children with SLI. In Italian children with SLI, they found the production of 3rd person plural (which involves adding an unfooted weak syllable in the final position) correlated with medial weak syllable deletion in monomorphemic words. In addition they found the use of articles correlated with initial weak syllable deletion.

However, phonological difficulties cannot fully account for the morphological errors seen in SLI. Although many children with SLI do have phonological difficulties which could affect their production of morphology, many children have difficulties with expressive phonology with no concomitant language impairments (Shriberg & Kwiatkowski, 1994). Thus, *expressive* phonological difficulties do not necessarily lead to language difficulties, although there are suggestions that children with SLI have difficulties with the mapping or linguistic aspects of phonology (Chiat, 2001; van der Lely, 2005). Children with SLI are also frequently reported to have difficulties with phonological awareness, although this does not seem to be restricted to SLI, as such difficulties have also been found in children with moderate sensori-neural hearing losses

(Briscoe et al., 2001) and reading impairments (Kamhi & Catts, 1986; Kamhi et al., 1988).

Phonological difficulties could also be evident in poor performance on non-word repetition tasks, but this task will be discussed separately in section 1.8 .

1.6.4 Lexical learning

The majority of studies of lexical learning involving children with SLI have found they can comprehend new words introduced in experimental learning situations as well as language matched controls (Leonard, Schwartz, Chapman, Rowan, Prelock, Terrell, Weiss & Messick, 1982; Schwartz, Leonard, Messick & Chapman, 1987; Schwartz, 1988; Rice, Buhr & Oetting, 1992; Ellis Weismer & Hesketh, 1996), although they showed poorer performance in one study (Rice, Buhr & Nemeth, 1990). Compared to *age* controls, children with SLI been found to learn fewer novel words (Rice et al., 1990; 1992; Oetting, Rice & Swank, 1995; Ellis Weismer & Hesketh, 1996), however, this masks areas of relative strength and weakness. They have been found to have particular difficulties learning verbs (Rice, Oetting, Marquis, Bode & Pae, 1994; Oetting et al., 1995; this will be discussed further in Chapter 2). In contrast, they have shown equivalent performance on noun learning to age controls (Dollaghan, 1987; Oetting et al., 1995; Rice et al., 1994), although in the Rice et al. study, only when they heard ten presentations as opposed to three. Studies which have also investigated the ability to *produce* new words showed the children with SLI were generally poorer than age controls (Dollaghan, 1987) and poorer than language controls when the words were presented in sentences spoken at a faster rate in the initial learning phase (Ellis Weismer & Hesketh, 1996).

1.7 Non-linguistic difficulties in SLI

Children with SLI frequently perform below the level of their peers on areas other than language. Difficulties with a variety of cognitive and motor skills have been found and are reviewed in Hill (2001) and Leonard (1998). These difficulties occur with greater frequency in the SLI population than would be expected by chance. However, only a few of these difficulties have been proposed as possible causes for SLI and only these will be discussed in the following sections.

1.7.1 Auditory processing

Significant differences between children with SLI and age-matched controls have been found in the discrimination of both non-speech and speech sounds. For non-speech sounds, they have difficulties discriminating the order of two tones of different frequency when presented with short duration intervals between them (less than 305ms) (Tallal & Piercy, 1973) and discriminating the 2nd formant transition involved in the ba/da distinction (van der Lely, Rosen & Adlard, 2004). As regards speech sounds they have difficulties discriminating the order of /ba/ vs /da/ (Tallal & Piercy, 1974; Tallal & Stark, 1981; Leonard, McGregor & Allen, 1992b; van der Lely et al., 2004), /ɛɪ/ vs /ɑɪ/ (Tallal & Piercy, 1975), /dɑ/ vs /tɑ/, /sɑ/ vs /ʃɑ/ (Tallal & Stark, 1981), /das/ vs /daʃ/ and /dabiba/ vs /dabuba/ (Leonard et al., 1992b).

In contrast they have no difficulty discriminating the order of two tones of different frequency when presented with longer intervals (more than 305ms) (Tallal & Piercy, 1973) or /ba/ vs /da/ when formant transitions are lengthened (Tallal & Piercy, 1975), /dab/ vs /dɑb/ (Leonard et al., 1992b; Tallal & Stark, 1981), /sɑ/ vs /stɑ/ (Tallal & Stark, 1981), /i/ vs /u/ (Leonard et al., 1992b) or /ɛ/ vs /ae/ whether presented briefly or for longer durations (Tallal & Piercy, 1974; Tallal & Stark, 1981).

These findings suggest that the underlying difficulty might be with processing brief cues when they are rapidly followed by other cues (Tallal & Stark, 1981). This suggests that the auditory difficulty could be tested with backward masking, where the detection threshold is measured for a brief tone presented immediately before a masking noise. One study found that SLI children are dramatically impaired in this area (Wright, Lombardino, King, Puranik, Leonard & Merzenich, 1997) but others have shown no significant difference between children with SLI and controls on this task (Bishop, Carlyon, Deeks & Bishop, 1999b; McArthur & Bishop, 2004). However, these latter two studies involved older children and children with SLI have been shown to improve their skills on auditory tasks with practice (Bishop et al., 1999b; Merzenich, Jenkins, Johnston, Schreiner, Miller & Tallal, 1996) and age (Bernstein & Stark, 1985). Indeed the Bernstein & Stark study showed that children with SLI aged 8-12 years as a group no longer had difficulties with auditory processing tasks even though they had had severe difficulties four years previously (Tallal & Stark, 1981).

Several studies have shown overlap between the performance of children with SLI and controls on auditory processing tasks with some children with SLI scoring in the normal range. On *non-speech* tasks, two studies found the majority of the (teenage) children with SLI performed within the normal range (van der Lely et al., 2004; McArthur & Bishop, 2004). On *speech* tasks, some children with SLI have also been found to perform in the normal range. Van der Lely et al. (2004) found 31% of their G-SLI subjects scored within the normal range. In the Tallal and Piercy (1974 & 1975) studies, 2 out of 12 children with SLI reached criterion with /ɛɪ/ vs /ɑɪ/ and /bɑ/ vs /dɑ/, thus showing no difficulties with the task and in Bernstein & Stark's (1985) study, at least two out of 29 had no difficulties even at the first time of testing.

Several studies also report children with normal language development who have difficulties with auditory processing tasks (Bishop et al., 1999b; van der Lely et al., 2004). Of the seven children in Bernstein & Stark's (1985) study who did still have severe difficulties at the later testing point, three had SLI, two were no longer classified as SLI but had a history of language impairment and two were control children who had never had any language difficulties. These combined findings of control children with auditory difficulties and children with SLI without them lead to claims that auditory processing difficulties are neither necessary nor sufficient to cause a language impairment (Bishop et al., 1999b).

However, it is still possible that all children with SLI may have had an auditory processing deficit at an earlier stage and this could have had a long-term effect on their language. It is therefore unfortunate that Bernstein & Stark (1985) did not carry out correlations between auditory processing at Time 1 and language at Time 2 as this could have revealed such an effect. Cross-sectional studies find no correlations of auditory processing with composite language scores or non-word reading (Bishop et al., 1999b), phonology or grammar (van der Lely et al., 2004). In contrast, a multiple regression analysis found 72% of the variance in receptive language could be accounted for by discrimination and sequencing of nonverbal acoustic tones and stop-vowel syllables with various duration formant transitions (Tallal et al., 1985), indicating a possible link. However, the results of this study should be treated with extreme caution, as the authors do not report the measure of receptive language used and appear to have entered approximately 50 variables (36 of which were auditory measures) into the regression with only 26 subjects, when the rule of thumb is at least ten subjects per predictor variable (Howell, 1997). Despite the lack of reliable correlations between performance on auditory processing tasks and language levels within the SLI population, all studies agree there is an unusually high incidence of difficulties with these tasks; this needs to be explained.

1.7.2 Working Memory / General Processing difficulties

Most studies of working memory are carried out within the framework of either the capacity model (Just & Carpenter, 1992) or the three component model of working memory (Baddeley, 2003), which involves a visuospatial sketchpad, phonological loop and central executive. Studies using Just and Carpenter's model focus on the trade-off between storage and processing of information when the amount of resources is exceeded by the demands of the task. Those working within Baddeley's model have tended to consider the phonological loop, which consists of a temporary storage system and a subvocal rehearsal system. Non-word repetition has frequently been used as a measure of the phonological loop, however this task also involves other aspects of language and processing and will be discussed in section 1.8.

Several studies have found children with SLI are equivalent to age matched controls at recalling items when maintaining sequential order is not required (Shear, Tallal & Delis, 1992; Gillam, Cowan & Day, 1995; Fazio, 1998; Montgomery, 2000a & b), although one has found they are worse than age controls (Kirchner & Klatzky, 1985). In contrast, they perform worse than age controls when they have to recall items in a specified order (Kirchner & Klatzky, 1985; Gathercole & Baddeley, 1990) or in semantic categories (Shear et al., 1992; Montgomery, 2000a; 2000b). Comparisons with language matched controls on serial recall tasks show either equivalent (van der Lely & Howard, 1993) or worse performance (Gathercole & Baddeley, 1990); this discrepancy may be due to differences in stimuli and experimental procedures.

Trade-offs between processing and storage can be investigated by varying speed of presentation (manipulating processing demands) and length (manipulating storage demands). Studies investigating the speed of presentation show increasing speed affects performance on serial recall (Fazio, 1998), word learning (Ellis Weismer & Hesketh, 1996) and comprehension of longer sentences (Montgomery, 2004) in children with SLI. However, decreasing the speed of presentation or adding pauses does not always improve sentence comprehension (Hayiou Thomas, Bishop & Plunkett, 2002). Studies which manipulate length have shown that children with SLI have more difficulties understanding longer redundant sentences than shorter non-redundant sentences (Curtiss & Tallal, 1991; Montgomery, 1995b; 2000a; 2000b; 2004). The studies by Montgomery found that the children with SLI understood the same number of short non-redundant (and fairly simple) sentences as age and language controls but for longer redundant sentences, they understood less than controls matched on receptive syntax.

Speed and length effects could be a result of difficulties with functional working memory (in Just and Carpenter's model) or the central executive (in Baddeley's model). Some studies provide evidence that children with SLI are worse than age controls on tasks of functional working memory or central executive, which require simultaneous storage and processing (Ellis Weismer, Evans & Hesketh, 1999; Montgomery, 2000a; 2000b; Marton & Schwartz, 2003; Hansson et al., 2004; Pickering & Gathercole, 2004; Archibald & Gathercole, ms).

Given that children with SLI as a group do seem to have difficulties with working memory and this could contribute to performance on linguistic tasks it is important to look for statistical relations between them. Unfortunately, working memory has not been found to correlate with any standardised language measure (Ellis Weismer et al., 1999), with word recognition reaction times (Montgomery, 2000a) or sentence comprehension (Montgomery, 2000a; 2000b) in children with SLI. The only exception to this is the study by Hansson et al (2004) which found correlations between working memory and most language measures in children with SLI. However, the working memory task was entirely linguistic and therefore any correlations are unsurprising.

1.8 Non-word repetition difficulties in SLI: linguistic and / or non-linguistic?

Non-word repetition tasks have consistently been found to cause difficulties for children with SLI relative to both age (or mental age)-matched controls (Kamhi & Catts, 1986; Kamhi et al., 1988; Gathercole & Baddeley, 1990; Bishop et al., 1996; Dollaghan & Campbell, 1998; Edwards & Lahey, 1998; Ellis Weismer et al., 2000; Briscoe et al., 2001; Montgomery, 2004) and language-matched controls (Gathercole & Baddeley, 1990; Edwards & Lahey, 1998; Briscoe et al., 2001; Montgomery, 1995a; 1995b; 2004). Indeed, difficulties with non-word repetition (particularly of longer words) have been suggested as a clinical marker for SLI (see section 1.2). These difficulties have been variously interpreted as being due to poor phonological short-term memory (Gathercole & Baddeley, 1990), difficulties forming phonological representations (Edwards & Lahey, 1998; Chiat, 2001) or difficulties with grammatical phonology (van der Lely, 2005).

Repeating non-words involves several processes 1) discriminating the acoustic signal, 2) segmenting phonological information, 3) encoding this into a phonological representation, 4) holding the representation in working memory and 5) planning and executing a response. Therefore the ability to repeat non-words relies on good auditory processing, phonology, working memory and motor planning and execution. It may be because it requires the integration of all these skills that children with SLI have such difficulties with this task. Poor performance on non-word repetition tasks could result from difficulties in any of these areas and indeed deficits have been found in all of these (reported in sections 1.7.1, 1.6.3 and 1.7.2). Theories of SLI (to be discussed in sections 1.10 to 1.11) have also been proposed which locate the underlying deficit in SLI with each of these stages of processing

However, any accounts of SLI which rely on the finding of difficulties with non-word repetition must explain why some other clinical groups have also been found to have difficulties with non-word repetition and yet do not have a language impairment. Some studies have shown that children with reading impairments also have more difficulties repeating multisyllabic non-words than mental or reading age matched controls (Snowling, 1981; Kamhi & Catts, 1986; Kamhi et al., 1988). Children with mild-to-moderate sensori-neural hearing losses (SNH) also perform worse on non-word repetition than age controls but at the same level as children with SLI (Briscoe et al., 2001; Norbury et al., 2001; 2002; Hansson et al., 2004) but have better scores on language and literacy tests than the children with SLI. Qualitative analyses in Briscoe et al. (2001) showed a drop-off with longer non-words in both groups, a finding which had been previously found by Gathercole and Baddeley (1990) and which they interpreted as due to a phonological short-term memory deficit. However, the children with SNH were no worse at a digit recall task than their age controls. This shows that these two tasks cannot tap the same underlying process. Briscoe, Norbury and colleagues therefore conclude that although auditory deficits could be at the root of some of the phonological impairments seen in children with SLI, they do not fully account for the combined language data of these studies.

Another difficulty for theories relying on non-word repetition difficulties is that not all children with SLI have difficulties with non-word repetition. Botting and Conti-Ramsden (2001) reported that 147 out of 200 children with SLI who scored below -1SD for their age on a non-word repetition test. Therefore, by implication, 53 must have scored within or above the normal range. Several researchers also report individual variation in scores amongst SLI children, with considerable overlap between their scores and those of control children (Edwards & Lahey, 1998; Montgomery, 1995b; Bishop et al., 1996).

Correlational evidence of a direct link between non-word repetition and linguistic measures in SLI is also inconclusive. Some studies have found correlations with expressive language (Edwards & Lahey, 1998) and sentence comprehension (Sahlen, Reuterskiold-Wagner, Nettelbladt & Radeborg, 1999; Sahlen, Wagner, Nettelbladt & Radeborg, 1999; Montgomery, 1995b), although this pattern of relationship does not always occur (Montgomery, 2004). Output phonology has also been shown to be linked to non-word repetition abilities (van der Lely & Howard, 1993; Edwards & Lahey, 1998; Sahlen et al., 1999). One study found that non-word repetition predicted all language measures apart from vocabulary (Botting & Conti-Ramsden, 2001). Indeed, a correlation with vocabulary has only been reported for children with SLI in one study (Hansson et al., 2004), while three report no correlation (Edwards & Lahey, 1998; Botting et al., 2001; Briscoe et al., 2001). This is despite such a correlation being found in typically developing (Gathercole & Baddeley, 1989; Adams & Gathercole, 1995; 2000; Gathercole, 1995a; Briscoe et al., 2001; Bowey, 2001) and hearing impaired children (Briscoe et al., 2001).

1.9 Summary of the data on SLI

Theories of SLI need to be able to account for poor performance on general language tests relative to peers as well as specific deficits over and above these general language difficulties. Morphology seems to be an area of particular weakness, particularly use of tense and agreement and to a lesser degree plurals. However, the cross-linguistic data show morphology is less vulnerable in languages with 'richer' morphology (e.g., Italian), which also use more vowels to mark inflections. Syntax has received less attention, but the evidence is that at least some children with SLI have significant difficulty with producing and comprehending passives, datives, *wh*-questions and embedded clauses. Difficulties with phonology, auditory processing, working memory and non-word repetition are common in children with SLI, but not all children with SLI have difficulties in these areas and such difficulties have also been found in children without language impairments. Evidence for correlations between these areas and language abilities within the SLI population is also weak. Theories of SLI should thus be judged on their ability to explain specific weaknesses in morphology and syntax and also account for generally delayed language and frequently co-occurring processing difficulties. In sections 1.10 and 1.11, I review linguistic and non-linguistic theories of

SLI. For each theory, I first detail its main claims and then consider how well it accounts for the data discussed in sections 1.6 and 1.7.

1.10 Linguistic theories of SLI

Linguistic theories of SLI claim that the difficulties of children with SLI are in specific areas of language; that innate language learning mechanisms are impaired in some way. Grammatical difficulties are seen as the primary deficits and other non-linguistic difficulties either as secondary deficits caused by the core grammatical difficulty or merely as co-occurring difficulties.

1.10.1 The "Feature Blindness/Rule Deficit Hypothesis" (Gopnik, 1990a; Gopnik & Crago, 1991; Gopnik & Goad, 1997)

The Feature Blindness or Rule Deficit Hypothesis was proposed to explain the difficulties of those with "genetic dysphasia", in particular the KE family. The data reported by Gopnik and colleagues reveal difficulties in morphology (and oral dyspraxia), but no difficulties with syntax. For this reason, they hypothesise that the underlying problem is "a selective impairment of that component of grammar that encodes abstract morphology". In particular, they claim the affected individuals lack "semantico-syntactic features" (Gopnik, 1990a), later called "abstract morphological markers" (Gopnik & Crago, 1991) or "morphological (sub-lexical) features" (Gopnik & Goad, 1997). Because they do not have these 'features' or 'markers', they cannot build inflectionally complex representations and therefore cannot construct the rules that operate on these features. Thus, the only way inflected forms can be learned is as independent items which are entered into the lexicon with specified meanings but which do not have any internal structure (in the same way as irregular forms). For this reason, they may be used interchangeably with uninflected forms either as meaningless phonological variants or as separate lexical items which are related in meaning e.g., *walk* means *move on foot* and *walked* means *move on foot in the past.* Thus regulars and irregulars are learned in the same way, accounting for the lack of the normal difference between regular and irregular verbs and also for the frequency effect found with regular verbs (discussed in section 1.6.1).

To account for the fact that the older members of the KE family were more proficient with their use of tense and agreement marking, Gopnik and colleagues hypothesised that they use explicitly taught rules to learn these forms. In other words, they use their other cognitive skills to compensate for a part of language (the grammatical "features") which is entirely missing. They may have been taught explicit rules such as "add *–ed* in the past tense" but these rules do not form part of their core linguistic competence and are not automatic. Over-generalisations such as "swammed" could be accounted for by use of both stored forms and explicit rules, where the stored past tense form is retrieved and the explicit rule "add *–ed*" is also applied.

A more recent version of this theory proposes that children with SLI have a deficit in the procedural memory system which is implicated in the learning of new motor and cognitive skills and 'habits' (Paradis & Gopnik, 1997). This presumes they have no implicit knowledge of at least some aspects of phonology and morphology and instead they make use of metalinguistic knowledge in declarative memory to construct their utterances. They claim such children learn their native language like a foreign language, through conscious application of rules and memorisation of forms, never really acquiring the rule-governed automatic use of markers, while their impairment becomes less obvious in conversational settings.

Given the different underlying genetic basis to the impairments in this family (as discussed in section 1.5), it is unclear to what extent this theory is generalisable to the general population of children with SLI. Certainly this group obtained different results in the area of syntax compared to those of the general SLI population studied by other investigators. This theory has difficulties accounting for the finding that errors in tense are usually omission and not commission errors (see section 1.6.1) which challenges the idea that morphological marked and unmarked forms are merely meaningless phonological variants. However, under the hypothesis that the semantics of time and number may be stored in the meaning of the verb, this is less of a problem. Other problems for this theory arise from cross-linguistic data. If children with SLI lack features, those speaking a language with a richer morphology (like Italian or Hebrew) should have more difficulties with inflectional morphology; however, the opposite is found (Miller & Leonard, 1998; Bortolini, Leonard & Caselli, 1998; Leonard et al., 1992a). The KE family have also been reported to have phonological difficulties, for which this theory has no explanation.

1.10.2 The Agreement Deficit Hypothesis (Clahsen, 1989; Clahsen et al., 1997)

Clahsen and his colleagues define the deficit in SLI as a selective impairment in establishing agreement relations in grammar (or optional non-interpretable phi-features of verbs in the later version). This hypothesis is based on their findings (listed in section 1.6.1) that children with "developmental dysphasia" mainly have problems with agreement and they are not impaired in their use of English past tense, German participle inflection, plurals, word order, or definite versus indefinite determiners. They propose this deficit would lead to problems establishing the structural relationship of agreement between two phrase-structure categories and thus would predict difficulties with subject-verb agreement, finite auxiliary, case markers and gender marking.

This theory accounts well for several of the deficits listed in Table 1.1, but does not account for any of the frequently reported deficits with tense marking. Indeed as remarked in section 1.6.1, Clahsen et al.'s own data for English do not show accurate marking for tense, especially considering the age of the children studied. This hypothesis also cannot account for the general language delay, or any syntactic or phonological difficulties or the cross-linguistic data from non-Germanic languages (e.g., Italian) which reveal errors on subject-verb agreement only for particular types of subject.

1.10.3 Extended Optional Infinitive (Rice et al., 1995)

Rice et al.'s (1995) view differs from the previous two hypotheses discussed, in that they see the underlying deficit as a *delay* specific to morpho-syntax (not a deficit as in the previous theories). This theory arises from the theory of the Optional Infinitive (OI) Stage of normal language development (Wexler, 1994) where young children do not know that tense is obligatory in main clauses, although they do know how to mark it (i.e., they have knowledge of the finite/non-finite distinction). The Extended Optional Infinitive hypothesis assumes that in children with SLI, the normal optional infinitive stage is prolonged and possibly even permanent, persisting beyond the time of mastery of other grammatical features. There is no real 'impairment'; they do know the properties of tense and agreement but do not know that main clauses must be obligatorily marked as finite. Therefore, they produce a higher proportion of non-finite matrix clauses than expected from their mean length of utterance and persist in producing non-finite matrix clauses to an older age than normally developing children.

This hypothesis accounts for many of the findings relating to morphology discussed in section 1.6.1, particularly those involving omission of tense or agreement. However, it has difficulty accounting for use of 'is' for 'are', frequency effects for plurals and past tenses and the loss of the usual advantage of regular over irregular past tenses. It also does not account well for any other difficulties with morphology or syntax or the cross-linguistic data which show that tense morphology may not be particularly affected in some languages.

1.10.4 Representational Deficit for Dependent Relations (RDDR) and Grammatical Complexity Hypothesis (CGC)

(van der Lely & Stollwerck, 1997; van der Lely, 1998; van der Lely & Battell, 2003; Marshall, 2004; van der Lely, 2005)

The three linguistic hypotheses discussed above only account for impairments in specific areas of morphology. The RDDR hypothesis accounts for the wide range of difficulties in syntax described in section 1.6.2 and some of the morphological difficulties described in section 1.6.1. An extension of the hypothesis currently under development, the Computational Grammatical Complexity Hypothesis (Marshall, 2004; van der Lely, 2005) also aims to account for some of the phonological and morphological difficulties. Van der Lely and colleagues hypothesise that the core deficit lies in the computational grammatical systems of syntax, morphology and phonology and within each system is related to grammatical complexity. With regard to syntax, the RDDR claims that the deficit is "with building nonelementary, complex dependencies". These long-distance dependencies necessitate movement, thus a deficit in these results in optional movement. This in turn leads to difficulties with binding, 'wh' questions and passives and (because of the role of movement in feature-checking) to difficulties with agreement, tense and case assignment. For comprehension, complex long-distance dependencies are not built, so the representation may be ambiguous and open to more than one interpretation. This can lead to difficulties comprehending non-canonical sentence structures (e.g., passives and datives) and also difficulties with binding and mapping thematic roles onto syntactic functions. The net result is that sentences with complex syntactic dependencies will sometimes be interpreted correctly and sometimes incorrectly, but there should be no difficulties with structures which do not involve such dependencies such as negation (Davies, 2002). The RDDR accounts for much of the syntactic (and some of the morphological) data, but it is as yet unclear how well it can generalise to other children with SLI outside the G-SLI subgroup.

1.11 Processing theories of SLI

Processing theories differ from the linguistic theories in that they reject the idea of an impairment in specialised linguistic mechanisms. They propose instead that children with SLI have lower level processing problems which are not specific to language but can cause language difficulties, either directly, or because certain aspects of language are particularly vulnerable. Therefore grammatical deficits are seen as a secondary, downstream consequence of lower-level perceptual deficits or connections between levels of language. The proposed processing difficulties range from specific to general.

1.11.1 Phonological processing difficulties

Some theories of SLI propose that the core difficulty in SLI is phonological processing (Joanisse & Seidenberg, 1998; Chiat, 2001) and that phonology is the key link between perception and grammar. These authors claim that phonological processing difficulties affect the development of phonological representations, which leads to limited vocabulary and also non-word repetition difficulties. They also propose phonological processing deficits could also impede learning of various grammatical structures and lead to difficulties comprehending long or complex sentences. This is because in order to process and understand such structures and sentences, it is necessary to retain the information in a phonological form while it is analysed.

The reasons proposed for the phonological impairment in SLI vary from author to author. Chiat (2001) proposes that the core difficulty is reduced access to the phonological details within rhythmic structures which disrupts the mapping between phonology and other levels of language. She claims these details are required for the establishment of lexical forms and syntactic structures and predicts more difficulties with lexical, morphological and syntactic forms where phonology has a greater role in cueing their semantics. She also predicts differential disruption of lexical, morphological and syntactic forms depending on their phonological complexity, with phonological factors compounding the effects of semantic factors. By this hypothesis, content words should be easier than phonologically weak function words and these should be less vulnerable in languages where they are more salient. Other authors (Joanisse & Seidenberg, 1998; Bernstein & Stark, 1985) propose phonological difficulties could stem from a lower-level perceptual difficulty, which if it occurs at a critical point in language development could cause a language deficit(Joanisse & Seidenberg, 1998; Bernstein & Stark, 1985).

1.11.2 Temporal processing deficit

(Tallal & Piercy, 1974; Tallal & Stark, 1981; Tallal et al., 1985; Tallal, Miller, Bedi, Byma, Wang, Nagarajan, Schreiner, Jenkins & Merzenich, 1996; Tallal, 2000)

Tallal and colleagues have proposed this lower level deficit to be a "temporal processing deficit". This hypothesis is based on data (discussed in section 1.7.1) that children with SLI have difficulty discriminating brief or rapid stimuli, although they have no difficulty with longer stimuli, or those presented at a slower rate. This hypothesis is strengthened by recent findings that training with speech stimuli in which the brief, rapidly changing components have been prolonged and emphasised, coupled with training exercises for temporal processing abilities, results in dramatic improvements in auditory processing and receptive language in children with language difficulties (Tallal et al., 1996; Merzenich et al., 1996). However, see Chapter 8 for a discussion of these studies.

Compared with some of the linguistic hypotheses discussed above, the temporal processing hypothesis can account better for the cross-linguistic findings which show that Italian children with SLI make fewer errors with agreement than English children, as the morpheme is represented by a vowel in Italian and is therefore more salient (Leonard et al., 1992a). However, it fails to explain why English children have difficulty with irregular past tenses, regular past tenses requiring /ɪd/ (Marchman, Wulfeck & Ellis Weismer, 1999) and pronoun case, none of which involve phonetically weak sounds. It also does not explain why English children with SLI appear to have more difficulty with 3rd person *–s* than plural *–s*, or account for some of their syntactic difficulties, for example with *wh*-questions and binding.

Temporal or auditory processing theories are challenged by studies which have failed to find consistent auditory deficits in older children with SLI (Bishop et al., 1999b; Hanson & Montgomery, 2002; van der Lely et al., 2004; McArthur & Bishop, 2004) or have found children with typical language development who do show auditory deficits (Bishop et al., 1999b; van der Lely et al., 2004). Another study found no heritable influence on auditory tests (Bishop et al., 1999a), in contrast to language tests. Such results have led several researchers to question whether an auditory impairment is a necessary or sufficient condition of SLI, even though it may often co-occur with SLI and affect the severity of the impairment. It may be that auditory deficits only contribute to a language impairment in children who are already genetically at risk (Bishop et al., 1999b). The perceptual / phonological theories are also challenged by the findings that children with moderate sensori-neural hearing losses have equal difficulties with phonological perception, memory and awareness (Briscoe et al., 2001) but score higher than children with SLI on a range of language measures (Norbury et al., 2001; 2002). These studies indicate that low-level problems in phonological discrimination cannot account for the distinctive syntactic deficits seen in SLI, as many hearing impaired children display phonological but not syntactic deficits.

1.11.3 Phonological short-term memory difficulties (Gathercole & Baddeley, 1990)

Gathercole & Baddeley (1990) also propose SLI is caused by specific processing difficulties, but not with phonology *per se,* rather with phonological short-term memory (Gathercole & Baddeley, 1990). This theory is based on their findings, discussed in sections 1.7.2 and 1.8, that children with SLI have more difficulties recalling serial lists of real words and longer non-words than either age or language controls. They proposed that the deficit is in the specialised short-term storage of phonological information in the phonological loop of working memory and that this deficit causes language impairments. In their view, a deficit in phonological short-term memory impairs the learning of new words and morphemes because temporary memory representations of the sounds of unfamiliar words and morphemes are used as a basis for construing a more permanent representation of word / morpheme phonology. It could also impair the ability to understand longer or more complex sentences, as the phonology of such sentences has to be held in the temporary store while they are encoded into a semantic/syntactic representation.

This hypothesis accounts for some of the difficulties with phonology, auditory processing and non-word repetition and also accounts loosely for the linguistic data in that it proposes that vocabulary and morphology will be generally difficult to learn, but it does not account for the precise patterns of strengths and weaknesses in morphology or syntax. It also has difficulties accounting for the findings that other clinical groups also have difficulties with non-word repetition but do not have language impairments.

The strongest evidence for the causal nature of a phonological short-term memory deficit in SLI would be a longtitudinal study showing that children's later language levels can be predicted from their earlier phonological memory measures. A study with this aim (Gathercole, Tiffany, Briscoe & Thorn, 2005, in press) selected children at age 5 with poor phonological loop skills and followed them up at age 8. At this later point, they fell into two groups: one group had severe and highly specific phonological loop deficits and were impaired on literacy but not language measures, the other had milder phonological loop deficits but more pervasive learning impairments, involving language, literacy and maths. The authors therefore suggest that poor phonological short-term memory scores arise from either a primary phonological loop deficit or a more general language impairment. For the language-impaired group, their language problems seem to be the source rather than the consequence of their low performance on phonological loop tasks. The profile of the non-language impaired group suggests persistent and specific phonological loop deficits constrain the acquisition of literacy but not language. This study then provides the strongest evidence to date that specific phonological memory deficits do not cause SLI.

1.11.4 Working memory / General processing difficulties

A recent study investigating the role of both the phonological loop and the central executive (Archibald & Gathercole, 2004, ms) found deficits on tasks tapping the central executive were more widespread in children with SLI than those tapping the phonological loop. Indeed, the profiles of working memory deficits found in the children with SLI were very rare in the general population. This suggests that the processing deficits in SLI may not be as specific as that proposed by Gathercole and Baddeley (1990), but may involve working memory more generally. Several authors have proposed that children with SLI could fail linguistic tasks because they have working memory difficulties. If a fixed capacity system is assumed (Just & Carpenter, 1992), children could fail on a task either because they have a limited capacity system (Leonard et al., 1992a; Leonard, 1998; Hansson et al., 2004) or because they have to allocate more resources to processing. The latter could be either as a result of slow and inefficient linguistic processing (Montgomery, 2002) or because of slowed general processing (Bishop, 1994a), leaving fewer resources for other aspects of the task in hand.

The Surface Hypothesis (Leonard et al., 1992a; Leonard, 1998) assumes that children with SLI have a general processing capacity limitation and processing phonetically weak information (such as word-final consonants and unstressed syllables) requires more resources. Leonard proposes that while children with SLI have sufficient resources to be able to perceive and produce such information in monomorphemic contexts, they may have insufficient remaining resources to hypothesise the grammatical functions of such forms and place them in morphological paradigms. In English this could lead to errors with tense, agreement and passives.

The Surface Hypothesis accounts well for cross-linguistic differences, as the performance of the children with SLI is predicted to be a function of the salience of morphemes in the particular language they are learning. This explains why Italian children with SLI make errors with morphemes requiring the production of non-final weak syllables but make fewer errors with verb inflections consisting of syllabic affixes. However as with the auditory hypotheses, it cannot explain those errors which do not involve morphemes with low perceptual salience (see section 1.11.1)

Difficulties with language tasks need not result from a limited capacity, but could result from generally slowed processing (Kail, 1994) in a normal but fixed capacity system, particularly if material is complex or if there is a time pressure (Bishop, 1994a). Bishop (1994a) assumes children with SLI do have underlying linguistic competence but they fail to apply their knowledge consistently because their processing capacity is exceeded. On this view, grammatical accuracy will vary according to the processing demands placed on the child. Bishop (1994a) provides support for this hypothesis with data showing that in production tasks, phonological errors increase with syntactic complexity of utterances and syntactic errors are more numerous when polysyllabic words are used in a sentence repetition task. This is the kind of trade-off which would be expected in a fixed capacity system where neither phonology nor syntax has become automatised. In comprehension tasks, slow grammatical encoding could mean that the child might find it impossible to keep up with incoming message fragments so that the resulting surface structures would be incomplete, leading to comprehension errors.

An alternative view of the effects of processing limitations could be that, because of their fundamental linguistic difficulties, children with SLI have to use more processing resources when carrying out linguistic tasks. They may be using compensatory mechanisms which are less ideally suited to the task and hence need more processing resources. Thus difficulties with working memory could *result* from underlying language difficulties rather than *causing* them. Indeed the majority of studies which have looked at functional working memory or central executive tasks have used tasks which involve linguistic processing, thus it is difficult to separate cause from effect. One study compared performance on a linguistic versus a spatial working memory task in 'poor reading comprehenders' (Nation, Adams, Bowyer-Crane & Snowling, 1999) and found that they were only impaired relative to controls on the linguistic task and concluded that the lower listening spans of poor comprehenders could be a direct reflection of their language comprehension difficulties. Replication of such a study with children with SLI would be informative.

Hypotheses of working memory or general processing difficulties have the advantage that they can account for a range of difficulties. However, this is also a disadvantage, as they need to be able to account for the co-occurrence of specific difficulties in some areas with relative strengths in others. If children have generally slow processing they should also have more difficulties in many other areas of cognition in addition to language. While this is the case for some children with SLI, it is not true for many, who can have normal skills in visuo-spatial processing for example.

Theories invoking general processing difficulties or slow processing often account for specific difficulties in terms of linguistic complexity, where more complex structures involve more processing. But such proposals begin to resemble some of the grammatical theories which also propose that children with SLI have difficulties with complex structures. The question is whether the underlying difficulty is linguistic, which means they have to use more resources to process linguistic material or if it is with generally slow processing, which means they run out of resources before they have had time to finish processing the material. Processing theories should predict correlations between working memory and language levels whereas linguistic theories will not. The lack of correlations between working memory and language tasks therefore argue against the processing view.

If we assume that linguistic deficits are not directly related to working memory, we can hypothesise that children with SLI have varying degrees of linguistic competence in the presence of varying working memory capacities. For each child, some linguistic tasks will be outside their competence and their performance will not improve however much the processing requirements are reduced. Other tasks will be well within their competence and can be processed fairly automatically and will also be unaffected by processing requirements as capacity will not be reached for these tasks. However, some tasks will be within their competence, but not yet automatic. These will require additional processing resources and performance could well be affected by processing factors such as speed and length. This effect would be greater on those children who have poorer working memory capacities. Therefore, working memory skills would only be expected to account for variance in the performance of children with SLI on linguistic tasks which are within their competence but not yet automatic. This could account for the lack of correlations of language levels with functional working memory despite evidence that length and speed affect performance on linguistic tasks.

1.12 Implications for intervention

Three key concepts underlie theoretical explanations of SLI and have profound implications for intervention. These are: language learning mechanisms, language competence and language performance. Linguistic theories of SLI propose specific deficits with the language learning mechanisms which affect both competence and performance. Processing theories on the other hand, propose normal language learning mechanisms but impaired performance. However, they vary in whether they consider the children to have normal language competence or not. They all propose that a mechanism external to language is responsible for poor performance on language tests, but some propose this affects language learning (hence impaired competence) while others propose that the children have intact competence but cannot show this because their processing difficulties lead to performance deficits.

If children with SLI have impaired language competence, a major focus of intervention should be to increase their linguistic knowledge. The method used is likely to depend on whether their language learning mechanisms are hypothesised to be impaired or not. If some aspect of the language learning mechanisms is missing or irretrievably impaired, providing enhanced but normal language stimulation should have little effect on language abilities. Intervention would need to teach compensatory strategies so the children can use their other strengths to learn language, much like learning a foreign language. If language learning mechanisms are unimpaired but some other impairment is causing the language difficulties, clinicians could choose 1) to work directly on these areas to remediate the underlying impairment and thereafter allow language learning to proceed as normal, or 2) to manipulate the linguistic input so that it is less susceptible to the impairment, or 3) to by-pass the impairment and teach language through other means (e.g., signs or symbols). If the child has poor language performance but intact competence (either in general or in specific areas), intervention is likely to focus on removing the barriers to the child revealing this competence. The focus in this case could either be on the child (by teaching them strategies for coping more efficiently with linguistic tasks) or on the environment (by ensuring the processing demands of the environment or linguistic input are reduced).

Comparisons of the effectiveness of different types of intervention based on these three key concepts and the principles outlined above, have an important role in testing theories. The next section outlines the specific predictions for intervention for the theories discussed in this chapter.

1.12.1 Implications of linguistic theories

Intervention based on Gopnik's Implicit Rule Deficit theory would need to focus on teaching the children explicit rules for inflection. They would need to have much practice at these so the rules eventually become more automatic. Intervention would also focus on teaching inflected forms as lexical items, making sure that the properties of time and number are stored as semantic features of the words so that two different inflections of the word do not become meaningless phonological variants.

Clahsen's Agreement Deficit hypothesis suggests intervention should focus only on agreement relations. The children would need to be explicitly taught the structural relations between items and taught the pairings between subjects (including case) and verb inflections.

Rice et al.'s Extended Optional Infinitive hypothesis varies from the other linguistic hypotheses in that it assumes that the children know the properties of tense and agreement but do not know that tense is obligatory in matrix clauses. Therefore intervention should focus on making the child aware of the obligatory nature of tense marking. This could be achieved by implicit or explicit feedback to the child that matrix clauses with non-finite verbs are unacceptable.

Intervention based on van der Lely's RDDR hypothesis would focus on a wider range of areas of language. The key feature of the deficit is proposed to be movement. Given that some movement is overt and some is covert, different strategies may have to be employed for the two types of movement. For overt movement, it would be possible to show the children the effects of movement for both comprehending and producing sentences such as passives and 'wh' questions (Ebbels & van der Lely, 2001). For tense and agreement it would be difficult to explicitly teach the children about feature checking, but it would be possible to teach the relationships between subjects and verbs for agreement and to explicitly teach the rules underlying tense. The CGC hypothesis predicts that for some children, intervention may need to focus on increasing their ability to deal with phonological and morphological complexity. As this hypothesis is still under development, it is not yet clear what form this would take.

All of the above assumes that intervention should only work on the core difficulties where the child with SLI scores below children with the same level of language. But this ignores the fact that the children score below their age level in many areas of language and require some help with these areas too if they are to achieve their educational and social potential. Therefore in practice it is unlikely that clinician would work solely on these areas of hypothesised core deficit.

1.12.2 Implications of processing theories

Tallal and colleagues' auditory processing theory implies that improving the processing of rapid or brief stimuli could improve language abilities. This would presumably need to happen before the children are 8 years of age as Bernstein & Stark (1985) found that auditory processing difficulties resolve anyway by this age in children with persistent SLI. The findings of some studies based on this hypothesis (Tallal et al., 1996; Tallal, Merzenich, Miller & Jenkins, 1998) are very dramatic (approximately 2 years progress in four weeks of intervention). The authors therefore suggest that the children did in fact have intact language competence and their auditory processing deficits were not enabling them to access this, otherwise it is very unlikely the children could have made such dramatic changes in such a short time. However, see Chapter 8 for more detailed discussion of these studies and other independent studies of this method.

Chiat's Phonological Mapping Theory and Leonard's Surface Hypothesis predict that intervention should focus on making more salient the contrasts encoded in phonetically non-salient morphemes. This could be achieved by placing them in more salient positions, for example utterance finally, or using signs, symbols or the written word to draw the child's attention to the contrast of interest. The clinician could also provide many examples of the target contrast in a clear way so that the child is able to form hypotheses about the nature of the contrast and hence build up morphological paradigms. Chiat proposes that a difficulty with phonological processing could lead to semantic and syntactic difficulties due to the reduced reliability of phonological bootstrapping. Intervention could then focus on increasing semantic and syntactic cues to enable the child to access meaning. This could involve providing the same word in several different contexts which are rich in semantics (for example in a story with picture or action cues) or in many different sentence frames.

Gathercole and Baddeley (1990) hypothesise that difficulties with phonological short-term memory lead to difficulties forming reliable phonological representations for new words. Therefore intervention should focus on increasing the child's access to the phonology of a new word when they learn it and also increasing their phonological awareness (for example through rhyming, segmentation and blending games).

Theories proposing limited processing capacity or slow processing suggest intervention which focuses more on the environment. Clinicians would need to ensure that the child has the maximum chance of processing, remembering and understanding what he has heard by encouraging those in his environment to use strategies such as pictures, symbols and signs, speaking slowly and 'chunking' long instructions into short simple sentences. Intervention could also be carried out with the child, teaching them strategies such as visualisation, chunking or verbal rehearsal to aid processing and retention of linguistic information. Increasing the automaticity of tasks would also be a priority, as this would free resources and allow the child to carry out further processing, thus improving linguistic performance. In contrast to the implications of linguistic hypotheses, any intervention which focuses on explicit teaching of linguistic rules should make things worse not better, as these would involve more processing.

1.13 Summary and a way forward

The field of SLI is characterised by seemingly contradictory data and interpretations. This may in part be a result of the heterogeneity of SLI and the fact that different labs have studied different groups of children, but it could also be the result of the limited amount of research in each area of language and cognition studied in this group of children. The area of morphology has been well researched and a general consensus has now been reached regarding the difficulties English children with SLI have in this area, although much more work needs to be carried out on other languages. Other areas (e.g., syntax, phonology, lexical learning and argument structure) have received much less research attention; often only one or two studies have been carried out on a particular area or structure. These studies may have used different methods, or children with different ages or profiles and perhaps predictably, the results often do not concur.

Given that the data are so unclear, it is unsurprising that theories conflict, as each is based on the data collected by its particular proponent. Some theories only aim to account for the purely linguistic difficulties experienced by children with SLI whereas others also aim to explain some of the other cognitive difficulties often associated with SLI. Theories vary on whether they account for differences in the abilities of children with SLI compared to age or language-matched controls. This has a profound effect on the breadth of a theory. In general, the majority of the linguistic theories are rather narrow, explaining only a few specific deficits compared to language controls, and giving little explanation for the high co-occurrence of other cognitive difficulties. The processing theories on the other hand, tend to be too broad. Often they predict a wider range of impairments than that which is consistently seen in SLI and they also do not always account for the fact that particular areas, such as morphology, are differentially impaired compared to other linguistic and non-linguistic skills.

The lack of consensus in the research community regarding the nature of SLI means clinicians either have to deliver broad eclectic interventions which include elements compatible with as many theories as possible or rely on their own (often intuitive) interpretation of the nature of the deficit formed through their clinical experience. Research into intervention however does not need to wait until one theory has been declared a 'winner'; indeed intervention could be used to evaluate theories. As long as the intervention method and the children involved are well described, such studies will not only provide valuable information about the effectiveness of different types of intervention but will also allow inferences to be drawn regarding the nature of the children's difficulties.

1.14 Outline and aims of thesis

This thesis aims to:

1. extend current knowledge of the nature of SLI by investigating
    a. the development of argument structure in typically developing children (Chapter 4) and children with SLI (Chapter 5),

b. non-word repetition performance: the links between this and other areas of linguistic performance (including argument structure) and the underlying reasons for difficulties with this task (Chapter 6), and

2. evaluate the effectiveness of intervention for secondary school aged children with SLI on argument structure, comparing interventions focusing predominantly on syntax versus semantics (Chapter 9)

A brief description of each chapter is given below:

PART 1 investigates argument structure in typically developing children and children with SLI. It also investigates the relationship between argument structure and other areas of language in these two groups of children.

Chapter 2 explains the theoretical background for studies of argument structure, discusses the development of argument structure in typically developing children and summarises studies investigating this area in children with SLI. This provides the motivation for the design of the experiments in Chapters 4 and 5.

Chapter 3 provides details of the participants in Chapters 4-6, including the selection and matching criteria. The standardised and non-standardised cognitive and language tests used throughout the thesis are described, as are the statistical tests employed.

Chapter 4 provides details of a verb video task designed to elicit a wide range of argument structures and investigates the abilities of typically developing children to produce and judge the correctness of a range of argument structures with a range of verbs.

Chapter 5 compares the performance of children with SLI with individually matched age and language controls on the verb video task. The implications for intervention are discussed.

Chapter 6 investigates performance on a non-word repetition test and the relation between this and other areas of linguistic performance (including argument structure). It also investigates the underlying reasons for any difficulties repeating non-words. Specifically it contrasts the effects of length and phonological complexity.

Chapter 7 synthesises the findings from Part 1 of the thesis. It proposes a model to account for the data in Part 1 and discusses the implications for intervention

PART 2 evaluates the effectiveness of intervention for secondary school aged children with SLI

Chapter 8 reviews intervention studies with school-aged children with SLI.

Chapter 9 investigates intervention for argument structure with secondary school aged children with SLI and contrasts two approaches: one is predominantly semantic and the other syntactic.

Chapter 10 provides a brief conclusion to the thesis.

CHAPTER 2 VERB ARGUMENT STRUCTURE: THEORY, ACQUISITION AND SPECIFIC LANGUAGE IMPAIRMENT

This chapter is divided into three sections. First, I provide a theoretical background to the study of verb argument structure. I then discuss the acquisition of argument structure by typically developing children. Finally, I review the literature on the abilities of children with SLI to learn and use argument structure accurately.

2.1 Theories of Verb Argument Structure

Verb argument structure contains information regarding the syntactic behaviour of verbs and acts as the interface between verb semantics and syntax. It includes information about which participants in an event are obligatorily expressed and the syntactic positions in which they should appear. The importance of verb argument structure is shown in the examples below:

1a) *the man is devouring
1b) *the lady is putting the cup
1c) *the girl is filling the water in the cup
1d) *the boy is pouring the cup with water

2a) the man is eating
2b) the lady is dropping the cup
2c) the girl is pouring the water in the cup
2d) the boy is filling the cup with water

The pairs of sentences in 1 and 2 (a-d) have identical syntactic structures, but the verbs in 1(a-d) cannot appear in these structures. The verbs in 1a) and 1b) both require additional participants in the event to be expressed in the syntax, either in the object position (1a) or as a prepositional phrase (1b). These participants are optionally expressed with the verbs in 2a) and b). The participants in the *pouring* and *filling* events of c) and d) are assigned to the incorrect syntactic positions in 1, but the correct positions in 2.

The literature in this area is greatly complicated by the variable use of terms. Roughly equivalent to the term "verb argument structure" are: 'predicate argument structure', 'subcategorisation frames', 'subcategorisations', 'syntactic frames', 'case frames', 'lexical forms', 'constructions', 'thematic/theta grids', 'thematic role structure' and 'lexical syntactic structure'. Another problem is that the term "argument" is used in different ways by different authors. Some use it to refer to semantic items (Pustejovsky, 1995), some to syntactic items (Grimshaw, 1990; Pustejovsky, 1991; Bierwisch & Schreuder, 1994; Goldberg, 1995) and some to both (Pinker, 1989; Haegeman, 1994; Levin & Rappaport Hovav, 1994; 1995). The clearest terminology distinguishes semantic and syntactic items clearly, referring to, for example, "semantic participants" versus "grammatical arguments" (Grimshaw, 1990), "conceptual arguments" versus "syntactic arguments" (Jackendoff, 1990) or simply "semantic arguments" versus "syntactic arguments" (Jackendoff, 2002). Throughout this thesis I will use the terms "semantic participant" versus "syntactic argument" (often shortened to "participant" versus "argument"). The distinction between these two concepts is crucial to understanding argument structure as only some semantic participants are obligatorily expressed as syntactic arguments. Semantic participants are part of the event conceptualised by the verb and syntactic arguments are semantic participants which are expressed in the syntax. Not all participants are obligatorily expressed in the syntax and are therefore optional syntactic arguments[1].

Jackendoff's (2002) example of the verbs *swallow, eat* and *devour* makes the distinction between the two concepts of semantic participants and syntactic arguments clear. Swallowing can conceptually involve either a *swallower* and a *swallowed item* (2 semantic participants) or just a *swallower* (1 semantic participant). These two concepts of swallowing are related to two different predicate forms with either one syntactic argument (*John swallowed*) or two (*John swallowed the sweets*). The first of these does not entail that John swallowed something; merely that he performed a swallowing action. In contrast, *eat* conceptually always involves both an *eater* and an *eaten item* (two semantic participants). However, one of them (the *eaten item*) need not be expressed as a syntactic argument (i.e., it is an optional argument). Hence, although it is possible to say both *John ate* and *John ate the sweets*, we know that John must have eaten something regardless of which syntactic form is used, as *eat* has two semantic participants. *Devour* differs again in that it also involves two semantic participants, but

[1] The distinction between optional arguments and adjuncts lies in whether they are semantic participants or not. Adjuncts are syntactic phrases which are not participants in the event conceptualised by the verb and hence are also not arguments. For example, the location in which something is eaten is not part of the event described by the verb *eat*. In contrast, the *eater* and *eaten item* are part of the event and thus are semantic participants and hence syntactic arguments. Thus, in the sentence *John ate the sweets in the kitchen*, *John* and *the sweets* are participants and arguments (although *the sweets* are optional, see below) and *in the kitchen* is an adjunct.

unlike *eat*, they must both be expressed as syntactic arguments (i.e., they are obligatory arguments): *John devoured the sweets*. Thus **John devoured* is unacceptable, unlike *John ate*. Similar examples can be found of verbs which involve three semantic participants, for example *serve* and *give*. Both of these verbs involve a person transferring something to another person, but *give* (when used with the standard meaning of transfer of possession) always expresses all three participants in the syntax: *Sarah gave Nigel the peas,* or *Sarah gave the peas to Nigel*. On the other hand, for *serve,* while the *server* is obligatorily expressed, the participant which is transferred is optional (*Sarah served Nigel*) as is the recipient (*Sarah served the peas*). Thus, verbs may have more participants than obligatory arguments but not less (with the exception of verbs such as *rain* which have no participants but one dummy argument *it* to satisfy syntactic principles). Jackendoff (2002, p134) claims that the obligatoriness of syntactic arguments is not predictable from semantics and must therefore be encoded as an idiosyncratic lexical property of each verb in each language. However, others have noted that there are semantic consequences of whether or not an argument is expressed (Pustejovsky, 1991; Hale & Keyser, 1993; Ritter & Rosen, 1998; 2000). For example, when a count noun is expressed with *eat* or *devour*, this implies a completed action (known as 'telic') where the referent of the noun has been completely consumed; however, when *eat* occurs without an object, an on-going activity is described which has no particular end-point (known as 'atelic').

Theories of argument structure can be broadly divided into two groups: lexical versus constructional theories. Lexical theories assume that verb semantics is key and argument structure is stored with, projected or predicted from the semantics of each verb (Pinker, 1989; Grimshaw, 1990; Dowty, 1991; Jackendoff, 1990; 2002; Levin & Rappaport Hovav, 1994; 1995). Construction theories on the other hand view argument structure frames (or 'constructions') as separate from verb semantics. These theories claim that constructions have meaning independently of the verbs they are used with and the meaning of a sentence is derived from the interaction of the meaning of the construction with the meaning of the verb (Goldberg, 1995; 1998; Croft, 1998a; 1998b). Rather than describing all lexical and construction theories, due to space restrictions I will focus on only two lexical theories (Pinker, 1989; and Jackendoff, 1990) and one construction theory (Goldberg, 1995) as the theoretical and intervention approaches in this thesis are based on elements of these three theories. Before discussing these, however, I will consider traditional lexical theories and review some of the reasons why these are inadequate for those areas of argument structure studied in this thesis.

2.1.1 Lexical theories

2.1.1.1 Traditional lexical theories

Many theories of argument structure refer to "thematic roles" which specify the role played by each semantic participant in an event or state. Other terms, which have been used to refer to approximately the same concept are: 'thematic relations', 'theta roles', 'participant roles', 'semantic roles', 'semantic cases' and 'deep semantic cases'.

Traditional lexical theories (e.g., Fillmore, 1968; Gruber, 1965; Jackendoff, 1972) listed thematic roles, which were seen as primitives. The most commonly used are listed below:

Agent: instigator of an action,
Patient: the person or thing undergoing the action,
Theme: person or thing moved by the action,
Benefactive/Beneficiary: the entity that benefits from the action,
Goal: the entity towards which the action is directed,
Source: the entity from which something is moved as a result of the action,
Location: the place in which the action or state is situated.

These primitive thematic roles were linked to positions in the syntax, or to grammatical relations (such as Subject and Object), according to a canonical scheme often using a "thematic hierarchy". Thematic roles were arranged in one hierarchy and grammatical relations in another. The higher thematic roles were linked to the higher grammatical relations and hence thematic roles predicted syntax. Examples from Bowerman (1990) are shown in Figure 2.1.

Agents are highest in the thematic hierarchy and if present (as in the first example), are linked to the highest grammatical relation in the grammatical hierarchy (the Subject). If no Agent is present (as in the second example), the next role in the thematic hierarchy (the Theme/Patient) is linked to the Subject. Thus, the Theme/Patient could link either to the Subject or Object position depending on whether an Agent is present or not.

Thematic hierarchy: AGENT THEME/PATIENT LOCATION/SOURCE/GOAL

Grammatical hierarchy: SUBJ OBJ OBLIQUE OBJECT

Johnny pushes the wagon

Thematic hierarchy: AGENT THEME/PATIENT LOCATION/SOURCE/GOAL

Grammatical hierarchy: SUBJ OBJ OBLIQUE OBJECT

The box stayed in the corner

Figure 2.1: Examples (from Bowerman, 1990) of the use of thematic hierarchies (from left to right) for linking thematic roles to grammatical relations,

The literature contains many disagreements about the number, name and function of the roles (see Bowerman (1990) and Gropen et al. (1991a) for a review), which not only makes the literature difficult to interpret, but also indicates that primitive thematic roles may not be the best way to explain the relationship between semantics and syntax. Traditional theories of argument structure also have other difficulties, two of which relate to the investigations in this thesis:

1) They predict that all verbs denoting the same event with the same set of participants should display the same linking pattern. For example, an event such as 'Matt causes water to move out of one container into another' could be described using the verbs *pour* or *fill.* Traditional approaches therefore predict both verbs should have the same linking pattern, but this is not the case: *Matt pours the water into the cup* vs. *Matt fills the cup with water.*
2) They have difficulty accounting for alternating verbs, which can appear with different linking patterns but still describe the same event. These include causative alternations (e.g., *Fred broke the cup* vs. *the cup broke*), locative alternations (e.g., *Alex spread the butter on the toast* vs. *Alex spread the toast with butter*) and dative alternations (e.g., *Mary gave the book to John* vs. *Mary gave John the book*).

2.1.1.2 Verb semantics in more recent lexical theories

More recent lexical theories of verb argument structure (such as Jackendoff, 1990, 2002 and Pinker, 1989) assume a compositional semantic structure for verbs. Jackendoff (2002) proposes that a lexical entry for a verb consists of a spatial and conceptual structure (in addition to a phonological and syntactic structure). He assumes that the spatial structure contains information which is irrelevant for syntax and does not need to be further decomposed (e.g., manner of motion, distinguishing verbs such as *walk* and *run*). In contrast, the conceptual structure contains all the components of a verb's meaning which are relevant for syntax (e.g., the differences between transitive and intransitive verbs such as *drop* and *fall*) and is formed using conceptual formation rules and a small group of functions such as GO, BE, CAUSE. Within the conceptual structure are slots for the non-linguistic components of verb meaning (e.g., the spatial structure). Pinker's (1989) description of verbs' semantic structures is very similar to Jackendoff's, except that he uses different terminology. He uses the term 'thematic core' to account for that part of verb meaning which has implications for syntax, and 'root meaning' for that part which does not. Accounts of children's learning of verb meaning and argument structure within this framework will therefore need to describe how children acquire both the 'spatial' and 'conceptual structures' or (in Pinker's terminology), the 'root meaning' and 'thematic core'. Such theories will be discussed in section 2.2.

These more recent lexical theories differ from the traditional theories as thematic roles are not viewed as primitives in their own right but are determined by their position in conceptual structure. However, these theories also include an additional level of analysis for thematic roles based on cause and effect relations, which avoids some of the difficulties encountered by traditional lexical theories (e.g., alternations and *fill* versus *pour*). Within Jackendoff's (1990) theory, this is captured in his 'action tier' and in Pinker's (1989) theory, in the verb's 'thematic core'.

2.1.1.3 Action tier (Jackendoff, 1990)

Jackendoff (1990) accommodates concepts of cause and effect relations within an extra tier of lexical conceptual structure: the 'action tier'. The roles in his action tier are the Actor (the participant who carries out the action) and Patient or Beneficiary (the participant affected by the action). The result of having two tiers is that participants in an event can have more than one thematic role, one from each tier. Jackendoff's (1990) proposed hierarchy of thematic roles assumes that where a participant has more than one thematic role, the role that is highest in the hierarchy is used for linking. The highest role in the thematic hierarchy is linked to the highest position in the syntactic hierarchy working downwards until all participants marked as arguments have been linked, see Figure 2.2. Thus, the thematic role linked to the Subject position is usually an Actor / Agent (*<u>Bill</u> pushed Sarah*), but if no Actor is present, the Patient / Beneficiary could appear in this position (e.g., *<u>John</u> received a book*), or in the absence of a Patient / Beneficiary, a Theme (e.g., *<u>The ball</u> flew through the air*).

Jackendoff's action tier can account for the dative alternation if one assumes verbs which can undergo the alternation have two conceptual structures. In one, the Goal (*John*) is also the Beneficiary in the action tier; this is higher in the thematic hierarchy than the Theme (*the book*) and hence assumes the first object position, resulting in the ditransitive syntactic frame (*Mary gave John a book*). In the other, *John* is not the Beneficiary, only the Goal and hence is lower in the thematic hierarchy than the Theme *(the book*). Thus, the Theme appears in the object position and the Goal in a prepositional phrase (*Mary gave the book to John*).

	Thematic hierarchy	**Syntactic hierarchy**
ACTION TIER	Actor / Agent	Subject
	Patient / Beneficiary	1st object
THEMATIC TIER	Theme	2nd object
	Location / Source / Goal	oblique object

Figure 2.2: Jackendoff's (1990) Linking hierarchy

An additional feature of Jackendoff's (1990 & 2002) theory is that participant positions in a verb's conceptual structure can be marked (or 'indexed') as obligatory or optional syntactic arguments. This can be used together with the linking hierarchy to explain the locative and causative alternations. Jackendoff proposes that for verbs which undergo the causative alternation, the Actor / Agent is an optional argument. When it is expressed, it is highest in the thematic tier and appears in the subject position (*<u>Fred</u> broke the cup*); when it is not expressed, the Theme is the highest in the hierarchy and appears as the subject (*<u>the cup</u> broke*). For the locative alternation, he proposes that verbs undergoing this alternation have two separate conceptual structures. In one, the Theme is indexed as an argument and because it appears above the Goal on the thematic hierarchy, it is linked to the object position (*the man is spreading <u>the butter</u> on the toast*). In the other, it is not indexed as a syntactic argument and hence the Goal is linked to the object position (*the man is spreading <u>the toast</u>*). The logic for explaining the difference between *fill* and *pour* is similar. For *fill,* the Theme is not an argument, so need not appear in the syntax and the Goal will therefore be linked to the object position (*he filled the cup*). However, for verbs like *pour*, the Theme is an obligatory argument and hence surfaces as the Object, above the Goal (*he poured the water into the cup*).

2.1.1.4 Thematic cores (Pinker, 1989)

Pinker (1989) dispenses altogether with thematic hierarchies and captures cause and effect relations using 'thematic cores'. These form part of the overall meaning of the verb and are associated with argument structures via a set of linking rules. The basic thematic cores and their associated argument structures are listed in Figure 2.3.

The traditional thematic role labels can be used as mnemonics for the positions in thematic cores but are not seen as primitives as in the traditional approaches. For example, the term Agent can be used as shorthand for the first argument of *cause*, Patient as the second argument of *cause* and Theme as the first argument of *go*.

Thematic core (semantics)	**Argument structure (syntax)**
X acts	Intransitive (unergative)
X is in or goes to a location or state	Intransitive (unaccusative)
X acts on Y	Transitive
X causes Y to go to Z	Transitive + oblique object (containing 'to')
X causes Y to go into a state (by causing Z to go to Y)	Transitive (+ oblique object (containing 'with')
X causes Y to have Z	Ditransitive

Figure 2.3: Thematic cores and their associated argument structures

Recall that in Pinker's (1989) theory, verb meanings consist of two parts: 1) the thematic core and 2) the root meaning, which contains verb specific information such as manner of movement/causation or type of change of state. The number of thematic cores is limited whereas the number of root meanings is not. Therefore, while each verb has its own root meaning, it shares its thematic core with a large group of other verbs. Because thematic cores link directly to argument structures, verbs which share thematic cores will also share argument structures. Pinker calls these groups of verbs 'broad conflation classes'. Within these broad conflation classes, he also proposes 'narrow conflation classes'; these are groups of verbs whose root meanings are closely related, for example verbs of 'motion in a lexically specified direction' (e.g., *go, come, fall, rise*).

Pinker (1989) explains alternations by proposing 'lexical rules' which take a verb with a particular thematic core and create a new verb sharing the same root but having an altered thematic core and hence a different argument structure. For example, the lexical rule for the causative alternation converts the thematic core *Y goes into a* *location or state* into *X acts on Y causing it to change state or location.* He proposes alternating verbs such as *break* have two lexical entries, one for each thematic core, but both entries have the same root meaning and phonological form. Such verbs can therefore appear in two argument structures, one for each thematic core (e.g., *the cup broke* vs. *Fred broke the cup*).

Lexical rules are restricted by 'broad range rules' which operate across all languages and 'narrow range rules' which are language specific and restrict the alternation to particular narrow conflation classes. For the causative alternation, a broad range rule operates which restricts use of the lexical rule to verbs involving direct physical causation. This restricts the alternation to verbs with the thematic core *X is in or goes to a location or state* ('unaccusative' verbs) and does not allow causativisation of verbs with the thematic core *X acts* ('unergative' verbs) because their action cannot be caused directly by an external agent (e.g., **Fred laughed his sister*). Narrow range rules also bar particular narrow conflation classes from entering into the alternation, for example in English, the following narrow conflations classes cannot causativise; they are always intransitive:

- verbs of motion in a lexically specified direction (*go, come, fall, rise*)
- verbs of emission (*bubble, ooze, glow*)
- verbs of coming into or going out of existence (*die, disappear, appear*).

Other narrow conflation classes of verbs cannot detransitivise; they are always transitive:

- verbs of causation of directed motion (*take, bring, raise*)
- verbs of killing, creating or destroying (*kill, create, assassinate*)
- verbs of inducing behaviour (*tickle, amuse, feed*)

The lexical rule for the dative alternation converts the thematic core *X causes Y to go to Z* to *X causes Z to have Y* (e.g., *Mary gave the book to John* vs. *Mary gave John the book*). Two broad range rules operate to restrict its use. The first is semantic and arises because the thematic core of the ditransitive argument structure entails the Goal possessing the Theme and hence the Goal (or indirect object) must be animate. However, possession can be used in a metaphorical sense to apply to messages or stimuli: *he told her a story*. The second broad range rule applies to English and is a morphological constraint where only verbs of Anglo-Saxon origin dativise, for example: *he gave the museum the picture,* but not **he donated the museum the picture.* Narrow range rules also restrict use of the dative alternation. For example, in English the following narrow conflation classes do not dativise:

- verbs of manner of speaking (*shout, scream*)
- verbs of continuous causation of motion in some manner (*pull, push, lower*)

The lexical rule for the locative alternation relates the thematic cores *X causes Y to move into/onto Z* and *X causes Z to change state (by means of moving Y into/onto it)* (e.g., *Alex spread the butter on the toast* vs. *Alex spread the toast with butter*). The difference in surface structure is due to a shift in the focus of what is affected (e.g., *the butter* or *the toast*). Examples of narrow conflation classes which cannot undergo the locative alternation are listed below. Some are restricted to the thematic core *X causes Y to move into/onto Z*, for example:

- verbs where a mass is enabled to move via the force of gravity (pour, spill)
- verbs of pure positioning (put, place, *hang, lean*).

Other verbs however, are restricted to the thematic core *X causes Z to change state by means of moving Y into/onto it,* for example:

- verbs where a layer completely covers a surface (*cover, fill*),
- where addition of an object to a location causes an aesthetic change in the location (*decorate*)
- verbs where an object or mass impedes the free movement through the object in which it is put (*block*)

Traditional theories had difficulties accounting for the use of verbs with different argument structures such as *fill* and *pour* to describe the same event. In terms of Pinker's (1989) theory, *pour* has the thematic core: *X causes Y to move into/onto Z*, while *fill* has the thematic core: *X causes Z to change state (by means of moving Y into/onto it)*. Thus, where the event could conceptually be associated with both these thematic cores and also with the root meanings of *fill* and *pour*, either verb could be used. However, both *pour* and *fill* belong to narrow conflation classes which cannot alternate in English. The underlying thematic core of *pour* links the Theme (usually liquid) to the direct Object position and the thematic core of *fill* links the Goal (usually a container) to the direct Object position. Accounts of the acquisition of argument structure need to explain how children learn to use alternations and hence how they acquire lexical rules and broad and narrow range rules. They also need to explain how the children identify the broad and narrow conflation class in which a verb belongs. This will be discussed in detail in section 2.2.2.

2.1.2 Construction grammar approach

Lexical theories such as those discussed above often account for alternations by proposing alternative lexical entries for verbs which are realized in alternative syntactic constructions. This appears a reasonable solution until one considers the wide range of constructions in which some verbs can appear (examples from Goldberg, 1995):

3a *Pat kicked the wall*

3b *Pat kicked Bob black and blue*

3c *Pat kicked the football into the stadium*

3d *Pat kicked at the football*

3e *Pat kicked his foot against the chair*

3f *The horse kicks*

3g *Pat kicked his way out of the operating room*

3h *Pat kicked Bob the football*

Goldberg (1995) claims that lexical theories would thus have to list eight different 'meanings' for *kick* ranging from *X acts on Y by X making contact with Y with a foot* to *X causes Y to have Z by X making contact with Z with a foot.* This seems to place an excessive load on the lexicon and memory. A similar problem arises with verbs which appear in non-canonical forms such as those in 4b and 5b below:

4a. *She baked a cake*

4b. *She baked Bob a cake*

5a. *He sneezed*

5b. *He sneezed the napkin off the table*

Lexical theories would have to hypothesise additional meanings for *bake* and *sneeze* to account for the b examples, possibly 4b: *X causes Y to have something by baking* and 5b: *X causes Y to move to a new location by sneezing*. However, to have such meanings listed in the lexicon seems unparsimonious.

Goldberg's (1995) construction grammar approach denies verbs like *kick, bake* and *sneeze* have distinct multiple meanings. She assumes that syntactic constructions are basic units of language and are inherently meaningful. She proposes that the meaning of constructions can be captured by structures such as *X CAUSES Y TO*

RECEIVE Z, X ACTS or *X CAUSES Y TO MOVE Z*; these are very similar to the thematic cores discussed by Pinker (1989) but are seen as belonging not to the verb but to the construction. In Goldberg's view, constructions are combined with verbs and the resultant sentence meaning is a combination of the verb and construction meanings. She proposes that the roles associated with the construction meaning (argument roles) are general roles such as Agent and Patient, while those associated with individual verbs (participant roles) are more specific such as *pusher* and *pushee*. In order to use a verb with a particular construction, the participant roles of the verb have to be fused with the argument roles provided by the construction. These roles can only be fused if one is an instance of the other, i.e., the *pusher* can be fused with the Agent, not the Patient and the *pushee* with the Patient, not the Agent. When the number of participant roles equals the number of argument roles (the canonical situation), the constructional meaning is redundant with the verb's meaning.

However, additional arguments can be added by the construction. Thus, in the examples *Pat kicked Bob the football* and *she baked Bob a cake*, the verbs only have two participant roles and the additional argument (*Bob*) is contributed by the ditransitive construction which also contributes the meaning 'transfer of possession'. Goldberg explains the causative alternation in a similar way, claiming it involves verbs (e.g., *break*) with only one participant (i.e., the item which breaks), where use of the intransitive is canonical, but a transitive construction can supply an additional agent and a causative meaning.

Goldberg's theory allows speakers more creativity than the lexical theories discussed above as they can use verbs with constructions which provide more argument roles than the verb provides participants. Thus, they can produce non-canonical sentences such as *he sneezed the napkin off the table*. The major constraint on such creativity is the compatibility between the meaning of the construction, the verb meaning and the referents of the noun phrases appearing in the construction. Thus, in this example, the sentence meaning is that *X caused Y to move off Z* (the construction meaning) *by sneezing* (the verb meaning). Because of the nature of *sneezing*, Y must therefore be light enough for X to move it by sneezing, thus *he sneezed the rock off the table* would only be possible if X or Y had special properties, such as X being a giant or Y being a very light rock. Thus, restrictions on the use of particular verbs with particular constructions depend not on linguistic rules, but on the interaction of the nature of the referents (provided by knowledge of the world) with the verb and construction meanings.

In a similar way, the constructional approach, does not assume a *linguistic* relationship between the two constructions involved in the locative and dative 'alternations'. It merely states that some verbs are compatible with both constructions; for example, the verb *give* is compatible both with the constructional meanings *X TRANSFERS Y TO Z* and *X CAUSES Y TO RECEIVE Z* because its specific participant roles can be construed as instances of the general argument roles in both cases.

2.1.3 A further note on the causative alternation

A major disagreement concerning the causative alternation is whether the intransitive form or the causative (transitive) form is basic. Several linguists view the intransitive form as basic and the causative form as derived (Pinker, 1989; Langacker, 1991; Goldberg, 1995; Ritter & Rosen, 2000). Others however, assume that the underlying representation of these verbs is causative and the intransitive form is derived (Jackendoff, 1990; Grimshaw, 1990; Pustejovsky, 1995; Rappaport Hovav & Levin, 1998).

These differing points of view are drawn together in Levin and Rappaport Hovav's (1995) book: *Unaccusativity* which considers the causative alternation in detail. They distinguish between rules acting on verbs with a *single* semantic representation and verbs with *two* (related) semantic representations. For verbs with a single semantic representation they propose two processes: ***causativisation*** and ***detransitivisation***. They propose that the majority of verbs undergoing the causative alternation are basically causative and undergo ***detransitivisation***. These verbs are externally caused (e.g., *break, open*), but do not lexically stipulate the volitional intervention of an Agent (unlike *kill, cut*). Where the resulting state can be conceived of as being caused by natural forces, the cause does not need to be specified in the syntax, resulting in the projection of just one argument and hence an intransitive (unaccusative) syntactic frame (*the cup broke*). This is similar to Jackendoff's (1990) approach.

They view another (much smaller) group of verbs as basically intransitive but able to undergo **causativisation** under certain circumstances. They reserve this process for unergative verbs of motion (where the subject is both Agent and Theme) which can causativise only if a prepositional phrase is added, e.g., *the jockey ran the horse around* *the field*. In this case, the direct object retains some degree of agentivity. This is similar to Goldberg's (1995) explanation.

They also propose that some verbs have two lexical semantic representations and hence two argument structures (like Pinker, 1989). However, they do not assume these are related by a rule, but view them as two separate verbs which have the same root meaning and phonological form. This is particularly the case for verbs which can be construed either as internally or externally caused including verbs of manner of motion (*roll, bounce*). The internally caused version of the verb is intransitive (e.g., *the girl rolled down the hill, the boy bounced into the room*) whereas the externally caused version is transitive *(the girl rolled the ball down the hill, the boy bounced the ball into the room,)*. The externally caused versions may also detransitivise if they meet the criteria for this (e.g., *the ball rolled down the hill, the ball bounced into the room*).

Other verbs which they also regard as having two lexical semantic representations (and hence two argument structures) are verbs of spatial configuration (e.g., *hang, lean*). The intransitive versions of these verbs are purely stative (e.g., *the shirt is hanging on the line, the broom is leaning against the table*) whereas the transitive versions are verbs of external causation (e.g., *the man is hanging the shirt on the line, the man is leaning the broom against the table*).

If the causative alternation is not a single process, as Levin and Rappaport Hovav (1995) propose, we would predict different patterns of learning amongst children for the different processes. No studies of children's use of the causative alternation have investigated this hypothesis in particular, but they do indicate differences between causativisation and detransitivisation. Therefore, this thesis will investigate children's use of the causative alternation in the light of Levin and Rappaport Hovav's hypothesis (see Chapters 4 & 5).

2.1.4 Summary and discussion of theories of argument structure

Thematic roles were once seen as the key to argument structure. Now they are either dispensed with completely (Goldberg, 1995) or are merely seen as mnemonics for positions in thematic cores (Pinker, 1989) or lexical conceptual structures (Jackendoff, 1990). In the two lexical theories discussed, these positions link to the syntax via linking rules or a linking hierarchy. The cause and effect roles of Agent / Actor and Patient / Beneficiary appear in the thematic core or action tier and are crucial for linking as they resolve some of the difficulties encountered by traditional lexical theories (such as the syntactic realisation of *fill* versus *pour* and alternating verbs).

Goldberg's (1995) constructional meanings take a very similar form to Pinker's (1989) thematic cores. The main difference between these two views is that Pinker views the thematic core as part of the meaning of the verb and hence when a verb is associated with a different thematic core, its meaning changes. Goldberg, in contrast, views the meaning of the verb as constant and the meaning of the whole predicate as resulting from the combination of the verb and construction meanings.

Argument structure alternations are dealt with in four different ways in the three theories discussed in this chapter. The first explanation involves proposing two separate semantic representations related by a 'lexical rule' (Pinker, 1989; and for the locative and dative alternations, Jackendoff, 1990). Levin and Rappaport Hovav (1995) use a similar explanation to account for verbs which can be conceived of as *either* externally *or* internally caused (*roll, bounce*) and verbs of spatial configuration (*hang, lean*). The second proposal is that the two forms of the alternation stem from a single semantic representation, but one argument is optionally expressed. Jackendoff (1990) uses this as an explanation for the causative alternation in general, while Levin and Rappaport Hovav (1995) use this to explain verbs of external causation which can occur spontaneously (*break, open*). The third proposal is that of the construction grammar approach (Goldberg, 1995, particularly for the locative and dative alternations) where argument structure alternations merely consist of two constructions which are related in meaning such that some verbs can appear with both constructions. The final explanation is that arguments can be added by the syntax, this is particularly in the case of causativisation of unergative verbs (Levin & Rappaport Hovav, 1995) or, for Goldberg (1995), causativisation in general and the use of the ditransitive construction with verbs which do not inherently imply transfer of possession.

Having explained how alternations come about, theorists need to explain how they are applied to new verbs and how their use is restricted. Pinker (1989) does this in terms of broad versus narrow range rules. Broad range rules determine where an alternation is possible and roughly correspond to Goldberg's (1995) compatibility requirement where the participant roles of the verb must be able to be construed as instances of the argument roles of the construction. However, in addition, Pinker claims narrow range rules restrict the use of broad range rules to particular narrow conflation classes of verbs within a language. Thus, new verbs are assigned to narrow conflation classes by virtue of their meaning and whether or not they alternate is determined by whether the narrow conflation class to which they are assigned can undergo the alternation or not. For Goldberg (1995), new verbs can be used with alternative constructions if they are compatible with the meaning of that construction, but her theory cannot fully account for the restriction of alternations.

As discussed in the introduction to this chapter, another important component of argument structure is whether semantic participants are obligatorily expressed as syntactic arguments or not. Jackendoff (2002) claims this is specified in the lexical representation of the verb. Goldberg (1995) claims that all participants which are 'lexically profiled' by the verb are obligatorily expressed as arguments. Nevertheless, she also notes that in certain circumstances participants can be left unexpressed: when their identities are irrelevant (e.g., *she ate all day*), or recoverable from the context (e.g., *Jo won*). However, only certain verbs can leave participants unexpressed (compare *I insist* vs. **I demand*) and thus, as Jackendoff (2002) claims, this must be a lexical specification of the verb.

2.2 Acquisition of verb argument structure by typically developing children

Accurate use of verb argument structure requires knowledge of the precise meanings of individual verbs and how their participants link to syntactic constructions (including which participants are obligatorily expressed) in addition to the rules underlying argument structure alternations and how these are restricted. This section focuses on possible mechanisms of acquisition of this knowledge.

2.2.1 Observational learning and associative pairing

In the initial stages of language learning, children need to rely on their general cognitive skills to infer the meanings of verbs (from observation of situations). Pinker (1989) suggests that they form conceptual structures of event types through observation across situations. It is then possible for them to pair conceptual structures with co-occurring phonological forms of verbs, thus providing them with a first guess as to the meaning of some verbs.

Several objections have been raised to this proposal, most vociferously by Gleitman and colleagues (e.g., Gleitman, 1990; Fisher, Hall, Rakowitz & Gleitman, 1994). They note that adults often do not use verbs concurrently with the event they denote (Beckwith, Tinker & Bloom, 1989) making it difficult for the child to identify the relevant event and hence the meaning of the verb. The pairings between verbs and events are also far less regular than the pairings between nouns and objects, because events consist of many subevents, each of which can be described by a different verb (e.g., *fall, drop* and *break* could all describe the same event where someone drops a glass causing it to break). Thus, principles proposed to account for fast mapping of nouns, such as Markman's (1989; 1994) ***Mutual Exclusivity hypothesis*** (where children assume that every object has only one appropriate label) and ***Whole Object constraint*** (whereby children assume novel nouns name whole objects), do not work well for verbs.

However, the strength of these objections can be reduced if we assume that children revise their hypotheses regarding verb meanings over time. Indeed, Clark (1993) notes that the full conventional meaning of words may only be learned months or years after they are first added to the lexicon. Such a learning theory reduces the problem of the weak correspondence of the timing of utterance of a verb and the situation to which it refers, as over multiple occurrences of the verb, the child should be able to identify those situations which are similar and hence most likely to be related to the verb meaning. Indeed, a simulation study of vocabulary learning (Gillette, Gleitman, Gleitman & Lederer, 1999) showed it is possible to identify the meaning of verbs with high imageability from observation alone. Pinker (1994a) refutes the necessity of temporal co-occurrence of the verb and the situation to which it refers as he claims that children have good abilities to infer the communicative intentions of others. Thus, when they observe situations they also infer what adults mean. For example, when a parent tells a child "eat your peas", the child is able to infer the parent's intention and the fact that the child is not in fact eating peas at the time of the utterance, does not mean that he cannot infer the parent's meaning.

When considering the acquisition of verb meanings, it is important to remember that (at least in lexical theories of argument structure) verb meanings consist of several parts and that only some of these are available to direct observation:

1. the ***thematic core or lexical conceptual structure*** of the verb, which is shared with other verbs and consists of:
    a. the thematic tier (dealing with motion and location)
    b. the action tier (dealing with cause and effect relations)
2. the ***root meaning*** of the verb, which is not shared with other verbs.

The root meaning of the verb and the thematic tier are potentially available to observation. In contrast, the action tier depends more on the focus of the verb and is less available to observation. Therefore, verbs such as *pay, buy* and *sell* which differ only in their focus will be difficult to distinguish from observation alone (indeed Gentner, 1978, found that these verbs may not be fully understood even by 8 ½ years of age). Other verbs such as *fill* and *pour* also differ primarily in focus, although over time, children may encounter situations which distinguish them (e.g., a glass which is only half-full = *pour* and a glass filled by rain = *fill*, examples from Pinker, 1989, p254). Until they do encounter such distinguishing situations however, they may hypothesise an incorrect action tier and hence thematic core for these verbs. Given that young children are biased towards noticing manner of action as opposed to change of state in events (Gentner, 1978) they are likely to hypothesise a change of location thematic core (*X causes Y to go to Z*) for both verbs, which will be correct for *pour*, but incorrect for *fill*.

Children could learn the argument structures of early acquired verbs directly by associative pairing of the phonological forms of verbs with specific constructions (Tomasello, 2000a). Indeed, several studies show that children in the early stages of language learning are conservative and tend to use verbs only in those constructions in which they have heard them (Maratsos, Gudeman, Gerard-Ngo & DeHart, 1987; Brooks, Tomasello, Dodson & Lewis, 1999; Brooks & Tomasello, 1999). This would explain why young children make few argument structure errors (Bowerman, 1982; 1988; 1990). At this stage, children may appear to use alternations such as the causative alternation with real verbs (as found by Braine et al. (1990) for *roll, bounce* and *turn*), but rather than using a productive alternation rule, they may have simply stored two semantic representations for each verb with two associated constructions.

2.2.2 Rule-based learning

Item-based associative learning may be satisfactory in the early stages of language learning, but as the child acquires more verbs, the demands on storage capacity increase. A rule-based system would lead to more efficient learning and storage. Jackendoff (2002) and Bowerman (1990) suggest that having stored the syntactic frames they hear used with particular verbs, children begin to notice commonalities in the meaning of verbs which appear in the same frames. They can then begin to infer the linking rules between verb lexical conceptual structures and syntax[2]. Once they have identified the linking rule which links Agent to Subject, they can use this to 'bootstrap' into the syntax of their native language and identify whether the Subject (=Agent) appears before or after the verb. Pinker (1989; 1994a) labels this process ***'semantic bootstrapping'***, as semantic knowledge is used to bootstrap (or cue the child) into syntax.

Linking rules can then be used to map the participants in a verb's lexical conceptual structure or thematic core onto the correct syntactic positions in syntactic frames as described in sections 2.1.1.3 and 2.1.1.4. Pinker (1989) calls this process (***'forward linking'***). Children can now use verbs in sentences even if they have only heard them in isolation (Braine, Brody, Fisch, Weisberger & Blum, 1990). However, this predicts that if they have stored the incorrect thematic core for some verbs, they will now start to use these verbs in incorrect syntactic frames. This is particularly likely to be the case for verbs which are less transparent to observation (e.g., *fill, pay, buy, sell*). Evidence for this is provided by Gropen et al.'s (1991b) finding that children (aged 2;6-5;11) seem to think *fill* means the same as *pour* and tend to use *fill* in the syntactic frame used with *pour*. Bowerman (1982) also reports that for a while (aged 4-6 years), her daughter Eva always used *fill* in the incorrect frame (e.g., "Can I fill some salt into the bear?"), despite having used it correctly when she was younger. This could be because her stored thematic core for *fill* is of the form *X causes Y to go to Z*, rather than *X causes Z to go into a state* and from the age of around 4 years, she used linking rules to create syntactic frames rather than merely using verbs in the frame used by adults. At around the age of 6 years, she may then have revised the thematic core of this verb, possibly using syntax as a cue (see section 2.2.2.2 below).

2.2.2.1 Acquisition of alternations

Children could acquire the rules of verb alternations in the same way as they acquire linking rules: by noticing similarities in meaning among verbs which behave in similar ways syntactically. Pinker (1989) hypothesises that children store verbs in groups according to the syntactic frame in which they occur (thus forming broad conflation classes, see section 2.1.1.4). They may then note that some verbs appear in more than one syntactic frame (i.e., alternating verbs) and hence belong to more than one broad conflation class. Then they could hypothesise the lexical rules which relate

[2] However, note that some authors (e.g., Pinker, 1989; Lidz, Gleitman & Gleitman, 2003) claim these rules are innate and the child does not have to learn or identify them

the thematic cores underlying the broad conflation classes involved in alternations. Once children have acquired these rules, they can begin to apply them to verbs with only one stored thematic core which fall in the same broad conflation class as verbs which they know alternate. Thus, the lexical rules become productive.

Three alternations are investigated in this thesis: the dative, causative and locative alternations[3]. Studies of children's acquisition of these alternations have focussed mainly on their use with novel verbs (discussed below) with very little attention given to their use with real alternating verbs. However, one elicitation study (Osgood & Zehler, 1981) considered the use of the dative alternation with the verb *give* by 48 children (aged 3-8 years). They found that while the children used both syntactic frames, they preferred the prepositional frame. No studies were found which have investigated the children's relative use of the two syntactic frames involved in either the causative or locative alternations. The only possible exception is the study by Braine et al., (1990) which considered verbs that were hypothesised to undergo the causative alternation. However, these belonged to the group which Levin and Rappaport Hovav (1995) claim do not undergo the alternation but have two separate semantic representations, and hence two syntactic frames (see section 2.1.3).

Definitive evidence of productive use of a lexical rule for alternations is provided by studies of novel verb learning where the children use verbs in a different syntactic frame from that in which they were presented. Gropen et al. (1989) investigated productive use of the dative alternation by presenting children (aged 5;0-8;6) with novel verbs in the prepositional frame and then eliciting the ditransitive frame. Several studies have investigated productive use of the causative alternation, showing children use causativisation for novel verbs presented only as intransitives and detransitivisation for novel verbs presented only in the transitive frame (Braine et al., 1990; Brooks & Tomasello, 1999; Brooks & Zizak, 2002), although the latter two studies found detransitivisation was far less productive than causativisation. No studies have investigated the use of the locative alternation with novel verbs

Further evidence for the productive use of alternations is provided by overgeneralisation to verbs which cannot undergo the alternation. Children have been found to overgeneralise the dative (Mazurkewich & White, 1984; Bowerman, 1988;

[3] The passive 'alternation' will not be considered here as many linguists propose that passivisation occurs in the syntax, not at the level of argument structure (Pinker, 1989; Jackendoff, 1990; Hale & Keyser, 1993). The difficulties children with SLI have with the passive are therefore discussed under syntactic difficulties in Chapter 1 (section 1.5.2) and not in this chapter.

Gropen, Pinker, Hollander, Goldberg & Wilson, 1989) and locative alternations (Bowerman, 1982) in their spontaneous speech. Unlike the dative alternation, the locative alternation can be overgeneralised in two directions: using the change of location construction with change of state verbs and vice versa. Bowerman (1982) reported overgeneralisation was much more common and persisted longer with change of state verbs, such as *fill* (e.g., "Can I fill some salt into the bear?") than change of location verbs, such as *pour* (e.g., "I poured you with water"). A similar pattern was found by Gropen et al. (1991b); children over the age of 3;5 made no errors with *pour*, while all children (aged 2;6 to 5;11) made errors with *fill*. They tended to use the verb *fill* in the two constructions of the locative alternation fairly equally, indicating that they viewed *fill* as an alternating verb. These errors decreased with age and adults made virtually no errors.

The causative alternation can also be overgeneralised in two directions: via causativisation and detransitivisation. Children have been found to causativise intransitive verbs in their spontaneous speech between about 3 and 8 years of age (Figuera, 1984; Bowerman, 1982; 1988) and can be encouraged to do so in elicitation studies from two years of age (Braine et al., 1990). They also make errors with judgment of causativisation errors (Hochberg, 1986). Detransitivisation has been reported from 4;2 in spontaneous speech (Figuera, 1984) but as with novel verbs, detransitivisation of real verbs is less common than causativisation in both elicited speech and in judgement tasks (Brooks et al., 1999; Hochberg, 1986).

Once children have learned to use alternations, they then need to restrict their use. Pinker (1989) suggests the restrictions take the form of broad and narrow range rules (discussed in section 2.1.1.4). Broad range rules operate across all languages and restrict alternations to particular thematic cores, while language specific narrow range rules further restrict the use of alternations to particular narrow conflation classes. In order to learn the narrow conflation classes for their language, children need to note which verbs belonging to a broad conflation class do and do not alternate and then note the semantic similarities between them. Having formed narrow conflation classes, they can then predict whether a verb can alternate or not by identifying the narrow conflation class in which it falls. Only two studies were found which have considered children's use and learning of these rules. Gropen et al. (1989) showed that children (from 5;0) have some awareness of broad range rules restricting use of the dative alternation while

Brooks and Tomasello (1999) showed children (from 4;6) have some awareness of narrow range rules for the causative alternation.

In order to form narrow conflation classes in the first place, children need to identify which verbs do not alternate, but how do they do this? Whereas hearing a verb in two syntactic frames can inform the child that a verb does alternate, hearing a verb in only one syntactic frame need not entail that it does not do so. The adults might simply have chosen not to use one syntactic frame in the particular situations the child happens to have witnessed. The child could use statistical evidence: the more frequently a given verb is heard in a single syntactic frame, the more likely it is that its non-occurrence in another frame is due to some restriction on its use in that frame. Thus, children are more likely to restrict high frequency, early acquired non-alternating verbs to single frames than low frequency or late acquired verbs. This process has been called 'entrenchment' by some researchers and such effects have been noted from 3 years of age (Brooks et al., 1999). Children could also use another form of indirect evidence in the input: if they hear a verb used in a linguistic construction that serves the same function as a possible generalisation of an alternation, they may infer the generalisation is not possible. For example, a child hearing *he made it fall*, may assume the verb *fall* cannot occur in the transitive construction **he fell it.* Some researchers have called this process 'preemption' and have noted such effects from 6 to 7 years of age (Brooks & Tomasello, 1999; Brooks & Zizak, 2002). Another possibility is that parents 'inform' their children that particular syntactic frames are disallowed with particular verbs. Saxton (2000) found that when Eve (from the Brown (1973) corpus) made a grammatical error, her parents often used the correct form in the immediately following utterance. Saxton argues that the adult's obvious preference for another form, signals a rejection of the child's attempt. Although he provides no examples of correction of overgeneralisation of alternations, Eve's parents do correct omitted arguments (discussed in section 2.2.3), suggesting that they are aware of argument structure errors. Children are likely to receive more of this kind of evidence for verbs which they use more frequently and thus are predicted to make fewer errors with verbs which are acquired early: this prediction is upheld for overgeneralisation of both causativisation and detransitivisation (Brooks et al., 1999).

Overgeneralisation of alternations need not only arise from a lack of knowledge of broad or narrow range rules, but could also arise from allocation of a verb to the incorrect narrow conflation class due to an imprecise or incorrect semantic representation. As discussed above, imprecise representations could arise particularly for verbs whose meanings are less transparent to observation (e.g., *fill, cover, pay, buy, sell*). Thus, children would be expected to make fewer errors as their semantic representations become more refined. The next section discusses a possible mechanism by which children could refine their semantic representations of such verbs.

2.2.2.2 Syntactic bootstrapping / reverse linking

Landau and Gleitman (1985) proposed that children use syntax to aid their acquisition of verb meaning, a process termed ***'syntactic bootstrapping'*** (Gleitman, 1990), although Pinker (1994a) argues for the more transparent description: ***'syntactic cueing of word meaning'***. Syntactic bootstrapping could enable children to distinguish between the thematic cores *X acts* and *X acts on Y*, by noting the number of arguments associated with the verb (Naigles, 1990; Naigles & Kako, 1993; Fisher, 1996; 2002). While Pinker (1994a) agrees that syntax can provide some clues as to verb meanings, he also argues that it provides no information regarding the verb's root meaning (e.g., the difference in meaning between *open* and *close*); it can only indicate a verb's thematic core.

Gleitman (1990) uses 'syntactic bootstrapping' as a global term but Fisher et al. (1994) divide this process into two parts: the ***'zoom lens'*** and ***'multiple frames'*** hypotheses. The ***'zoom lens'*** hypothesis describes how syntax can act as a lens, providing information regarding the focus (or action tier) of verbs which are less transparent to observation, such as *fill/pour* and *pay/buy/sell*. This can be achieved by applying linking rules in reverse: ***'reverse linking'*** (Pinker, 1989; 1994a). For example, *buy* and *sell* both involve two Agents, one causing the transfer of goods and one the transfer of money, but the two verbs differ in which Agent is the focused Actor on the action tier (using Jackendoff's 1990 terminology). In Jackendoff's hierarchy (see Figure 2.2), the Actor is linked to the subject position and hence by identifying the Subject of the sentence, the child can identify which Agent is also the Actor (e.g., *<u>the boy</u> buys the toy from the lady* vs. *<u>the lady</u> sells the toy to the boy*). The verbs *pay* and *buy* have the same Actor but involve two Themes (money and goods). In their prepositional forms (e.g., *the boy pays <u>£5</u> to the lady* and *the boy buys <u>the toy</u> from the lady*), the Theme is linked to the object position and hence by noting which participant is in the object position, the child can identify which Theme is focused for each verb and hence distinguish their thematic cores.

A similar strategy could be used to distinguish *fill* from *pour.* As discussed above (section 2.2.1), children using observation alone are likely to hypothesise the thematic core *X causes Y to go to Z* for both of these verbs. However, if they note that for the verb *fill*, the Goal in the lexical conceptual structure appears in the object position, this should encourage them to reanalyse this verb's stored thematic core and hypothesise that the focus of *fill* is on the 'affected' Goal. Thus, the most parsimonious thematic core is *X causes Y to go into a state.* Children could use syntactic bootstrapping in this way to change the thematic core of known verbs and refine their semantic representations to a more adult-like form. Evidence that young children are willing to change (or ignore) the stored thematic cores of known verbs in response to evidence from syntax is provided by two studies (Naigles, Fowler & Helm, 1992; Naigles, Gleitman & Gleitman, 1993). These studies revealed that when children are provided with a known verb in a new syntactic frame (e.g., *the tiger goes the lion*), they enact events which comply with the thematic core predicted by the syntactic frame rather than that stored with the verb (e.g., they enact the tiger making the lion move).

The utility of a syntactic frame to indicate verb meaning is greatly limited if the child has no conceptual structure with which to link it (i.e., if the child has not observed any events involving the verb and only heard it in a sentence). If we use Jackendoff's (1990) linking hierarchy (see Figure 2.2), we can see that reverse linking in isolation is probabilistic at best because of the one to many mappings from syntax to semantics. For example, if the child hears a transitive sentence, reverse linking could give any of the following options for the thematic roles associated with the subject and object positions:

a) Actor & Patient (e.g., *the boys popped the balloons*),
b) Agent & Theme (e.g., *the boys threw the balloons*),
c) Beneficiary & Theme (e.g., *the boys received the balloons*)
d) Theme & Location/Goal (e.g., *the balloons filled the room*).

However, simultaneous observation of an event (as in the zoom lens hypothesis), would allow the child to distinguish between many of these possibilities. Options a) and b) could be distinguished by observation of whether *the balloons* change state (Patient) or location (Theme). Options b) and c) could be distinguished by observing whether *the boys* caused *the balloons* to move (*boys*=Agent) or whether someone else caused *the balloons'* motion and *the boys* merely benefited from this (*boys*=Beneficiary). The fourth option d) could be distinguished from the others as such an event or state would involve no participants which cause or benefit from the event. Thus, when reverse linking is used together with observational learning as in the 'zoom lens' hypothesis, it is very powerful, but when used in isolation it is an unreliable indicator of a verb's thematic core. However, when learning abstract verbs, observational cues are not available (Gillette et al., 1999). Thus, children have to rely on reverse linking and the discourse context alone to interpret such verbs.

The ***'multiple frames'*** hypothesis (Gleitman, 1990; Fisher et al., 1994) aims to overcome this limitation of reverse linking by proposing that children can use syntactic cues from multiple syntactic frames to provide converging evidence about a verb's meaning as "the syntax of verbs is a quite regular, although complex, projection from their semantics" (Fisher, Gleitman & Gleitman, 1991). However, as discussed above, syntactic frames only reveal those aspects of a verb's meaning that have consequences for syntax (i.e., the thematic core) and not the root meaning of a verb. Nevertheless, in the later stages of language learning, the range of syntactic frames appearing with an individual verb could enable the child to identify some features of a verb's root meaning, but only if they already know the narrow range rules and narrow conflation classes for their language (discussed in section 2.1.1.4). Pinker (1989, 1994) argues that children could triangulate a verb appearing in a particular combination of frames to a particular narrow conflation class. Thus, the verb would inherit the meaning features associated with its identified class. However, these rules are highly specific to individual languages and dialects and so to exploit these, the child would have to learn these subtle subclasses first. In addition, the use of multiple syntactic frames still would not allow the child to distinguish between verbs which belong in the same narrow conflation class (e.g., *shout* vs. *whisper*, *roll* vs. *slide* or *take* vs. *bring*) as these cannot be distinguished syntactically.

In summary, for children to learn both the root meaning of the verb and the thematic core, they need to use both multiple observational and syntactic cues in tandem. Observational cues provide information regarding the root meaning of the verb and indicate the verb's thematic tier. Syntactic cues on the other hand provide information regarding the verb's action tier, thus enabling the child to distinguish verbs which differ only (or primarily) in the perspective they take on the event.

2.2.3 Obligatory arguments

How typically developing children learn whether arguments are obligatory or not has received little attention. This is unfortunate since the literature on SLI (discussed in section 2.3) indicates that children with SLI have difficulties with this and understanding how typically developing children learn about obligatory arguments might provide a clue as to the knowledge which is defective in SLI. However, some studies provide indications that typically developing children do omit obligatory arguments. One study of SLI (King & Fletcher, 1993) lists examples of omission of obligatory arguments by typically developing children aged 3;0-5;4, while another found occasional omissions of the 'subject', 'theme', 'copula' and 'goal' by typically developing children aged 5;5-9;8 (Thordardottir & Weismer, 2002).

How is a child to know whether an argument is obligatory or optional? Marking an argument as optional is unproblematic as the child can use positive evidence from the input. If an adult sometimes uses and sometimes omits an argument, the child can mark it as optional. However, if adults always use an argument, this is not definitive evidence that it is obligatory, it could still be optional and by chance, the child has only heard sentences where it was included. Children may mark obligatoriness statistically: the more times they hear a verb with a particular argument, the more likely it is that the argument is obligatory. Thus, their ability to mark an argument as obligatory will improve with the number of examples they hear and thus is likely to correlate and with the verb's frequency in adult speech.

Alternatively, the children's parents could 'inform' them when they have omitted obligatory arguments. Indeed Saxton (2000) found that Eve's parents provided direct negative evidence, by including the omitted argument in the immediately following utterance, for both omitted Subjects and Objects. Evidence of this kind would also lead to a verb frequency effect, but in this case it would be verbs which the *child* uses frequently which are learned first, as they are likely to make more errors (and receive corrections) sooner with these verbs.

The child's task is further complicated by the fact that for some verbs, arguments are optional only if they are 'prototypical' (Rappaport Hovav & Levin, 1998). For example, the verb *sweep* prototypically involves *the floor* thus, it is possible to say *she is sweeping* and not express the affected participant (*the floor*). However, if the surface participant is not prototypical, it cannot be omitted; hence it is not possible to say *she is sweeping*, when the ceiling is being swept! Thus, the specific participants in the event can determine whether arguments are obligatory or not.

2.2.4 Summary of argument structure acquisition

In section 2.2, I have reviewed hypotheses regarding the mechanisms which underlie children's learning of verb meanings and argument structure. These mechanisms may apply at different times. Therefore, drawing on the hypotheses of a range of researchers (especially Pinker, Jackendoff, Gleitman, Fisher, Tomasello, Bowerman, Gropen and Saxton, see references in the main section) I have outlined a possible developmental progression, which I will summarise here.

Initially children use ***observational learning*** to form conceptual structures through observation across situations (Pinker). They then use ***associative pairing*** to pair the phonological form of verbs with these conceptual structures (Pinker); this enables them to identify the root meaning and thematic tier of the verb. They may also pair verbs with the syntactic frames in which they are heard (Tomasello) leading to use of the correct frame in the early stages of verb learning. They can then infer the linking rules between the semantics of known verbs and syntactic frames (Jackendoff and Bowerman). Once these linking rules are in place, the children can use verb semantics to access the syntactic structure of their language: ***semantic bootstrapping*** (Pinker). Also, they can predict the syntactic frame from a verb's stored thematic core, via ***forward linking*** (Pinker). At this point, they may begin to make argument structure errors for verbs which have incorrectly stored thematic cores (due to difficulties identifying the action tier from observation alone). In order to refine the stored thematic cores for verbs, children need to be able to identify the action tier and this is best done from analysis of the syntactic frame in which the verb appears: ***syntactic bootstrapping*** (Gleitman and Fisher). This can be done by applying the linking rules in reverse: ***reverse linking*** (Pinker). However, this is probabilistic due to the one to many mapping between syntax and semantics, so is best used in conjunction with observation of events (the ***zoom lens hypothesis***, Fisher, Pinker). When observational cues are not available, children could use ***multiple frames*** to help them predict the thematic core of new verbs (Gleitman and Fisher). However, this is only useful once the children have acquired the narrow range rules restricting alternations, discussed below, as they can then triangulate a verb to a narrow conflation class of verbs (Pinker).

Thus, the most effective learning of verb meanings and argument structures results from parallel use of observation with associative pairing and syntactic cues. Observational cues provide information regarding the root meaning of the verb and indicate the verb's thematic tier. Syntactic cues on the other hand provide information regarding the verb's action tier. This is particularly important for those verbs whose meanings may be less transparent to observation (e.g., change of state verbs, like *fill* and *cover*, or verbs which differ only in the perspective they take on events, like *buy, sell, pay*). Thus, if children fail to use syntactic cues, they may make errors with such verbs. Some evidence of difficulties with change of state verbs is provided by Gropen et al. (1991b) for *fill*. Bowerman (1982) also lists errors with other change of state verbs like *cover* and *pinch* but these are not always consistent. Such inconsistent errors could arise from overgeneralisation of the locative alternation, rather than applying linking rules to an incorrect thematic core. Bowerman (1982) states that for her two children, the majority of verbs which were used in the incorrect syntactic frame, were also used in the correct frame on other occasions (implying overgeneralisation of an alternation rule). However, for a while, Eva always used *fill* in the incorrect frame (implying storage of the incorrect thematic core). Thus, the reason for the underlying errors may differ from child to child and for each child from verb to verb. Information regarding the consistency of errors is therefore vital for understanding the underlying reasons for each child's errors. Bowerman's (1982) data only involve two children and while Gropen et al.'s (1991b) study involves 48 children, individual data are not provided. Thus, in Chapter 4, I will compare children's abilities to use change of state verbs and will carry out individual analyses in order to establish whether errors are consistent (implying an incorrect thematic core) or inconsistent (implying overgeneralisation of an alternation rule).

The acquisition of alternations draws on many of the mechanisms mentioned above. Once children have stored argument structures with verbs, they may note which verbs occur in more than one argument structure and hypothesise lexical alternation rules enabling generalisation of the alternation to other verbs. Overgeneralisations are inhibited when they identify broad and narrow range rules (Pinker). In order to do this they need to identify which verbs do not alternate, possibly by relying on statistical evidence and / or parental corrective feedback (Saxton).

The literature on the development of argument structure focuses mainly on the gradual appearance and then reduction in overgeneralisations of verb alternations. However, the ability to use alternations correctly does not just involve the avoidance of errors, but also the flexibility to use both frames involved in the alternation. Children's developing use of alternations with real verbs which *can* alternate has received very little attention and has only been studied in the dative alternation (Osgood & Zehler, 1981). Therefore, Chapter 4 will investigate children's use of all three alternations with alternating verbs. It will also aim to establish whether they prefer any particular syntactic frame as this could indicate which frame they regard as basic. This in turn could have implications for the theories of argument structure alternations.

The theories discussed in section 2.1, differ as to which syntactic frame of an alternation is regarded as basic and which as derived. For the dative alternation, the prepositional frame is most likely to be basic and the ditransitive frame derived, because no verb appears only in the ditransitive frame whereas many verbs appear in only the prepositional frame and not the ditransitive frame. For the locative alternation, Pinker (1989) states that either frame could be basic and that this may vary from verb to verb. For the causative alternation, some theorists (e.g., Pinker and Goldberg) regard the intransitive frame as basic and the transitive frame as derived, while others (e.g., Jackendoff and Levin and Rappaport Hovav) regard the transitive frame as basic and the intransitive frame as derived. Child and adult preferences for one frame or the other for particular alternating verbs could provide an indication as to which frame they regard as basic. However, no studies were found which have analysed child or adult preferences for particular syntactic frames with alternating verbs on a verb-by-verb basis. Thus, in Chapter 4, I will analyse children and adults' preferences with individual verbs with the aim of establishing which syntactic frame (if any) is preferred by either group and whether preferences change with age.

Once we have established whether children can use alternations, we also need to ascertain whether they have learned to restrict their use. Gropen (1991b) and Bowerman (1982) report more persistent overgeneralisation of the locative alternation for change of state (e.g., *fill*) than change of location verbs (e.g., *pour*); Chapter 4 will investigate whether such errors can be elicited from older children.

Chapter 4 will also investigate children's ability to use obligatory arguments. The mechanisms discussed for marking arguments as obligatory for particular verbs are statistical evidence and parental corrective feedback. It is therefore predicted that children's use of obligatory arguments will improve with experience of the verbs and hence correlations between use of obligatory arguments and verb frequency will be carried out. No studies were found which have investigated this area in typically developing children and thus Chapter 4 will provide a first step in this direction.

2.3 Verb argument structure in children with SLI

2.3.1 Predictions from theories of SLI

The theories of SLI discussed in Chapter 1 make differing predictions regarding whether children with SLI are likely to have difficulties with verb argument structure or not. Three of the linguistic theories: the Feature blindness / Rule deficit (Gopnik & Goad, 1997), Agreement deficit (Clahsen et al., 1997) and Extended Optional Infinitive (Rice et al., 1995) hypotheses, are designed to explain difficulties only with tense and agreement. Thus, they make no predictions regarding whether children with SLI should have difficulties learning verbs or verb argument structure.

The other linguistic theory discussed in Chapter 1: the Representational Deficit for Dependent Relations (RDDR, van der Lely, 1998) / Grammatical Complexity Hypothesis (CGC, van der Lely, 2005) claims that children with SLI have difficulties forming syntactic representations. Some rule-based aspects of the learning of argument structure rely on the use of syntax. These include: reverse linking, hypothesising lexical alternation rules and the ability to use statistical information or parental corrective feedback. Difficulties in these areas could lead to errors with verbs which are less transparent to observation (such as change of state verbs *fill* and *cover*), difficulties learning lexical alternation rules and hence using both forms of alternations and also poor learning of narrow range rules and the obligatoriness of arguments. Thus, any difficulties in these areas could be accounted for by these theories. If difficulties with argument structure are caused by syntactic difficulties, correlations between argument structure performance and syntactic measures would be predicted.

Several more general processing theories of SLI also predict very similar difficulties with rule-based learning, not because of syntactic difficulties, but because they hypothesise that children with SLI forget the details of the sentences due to slow processing (Bishop, 1994a), limited processing capacity (Leonard, 1998) or short-term phonological memory (Gathercole & Baddeley, 1990). However, these theories would predict that argument structure performance should correlate with working or short-term phonological memory measures but not with measures of grammatical complexity (unlike the RDDR).

The more specific processing theories vary as to their predictions regarding argument structure learning. The Temporal Processing Deficit hypothesis (Tallal et al., 1996) would not predict particular difficulties with argument structure as this relies little on processing phonetically weak sounds. On the other hand, Chiat's (2001)

Phonological Mapping hypothesis predicts that children with SLI should have difficulties at all levels of learning argument structure. Chiat claims that difficulties identifying the precise phonological details within sentences leads to difficulties identifying syntactic structures and this in turn leads to difficulties with rule-based learning. However, this theory also predicts children with SLI will have difficulties with observational and associative learning as these require the child to remember the phonological representation of a given verb across multiple events and to pair this representation with the conceptual structure given by the event and also with the syntactic structures used by the adults. Thus, Chiat's (2001) theory predicts the most wide-ranging difficulties with learning argument structure and would also predict correlations between argument structure performance and measures of phonological abilities.

In Chapter 5, I will therefore investigate whether children with SLI have difficulties with argument structure and whether there are any correlations between this and measures of syntax (as per the RDDR). Chapter 6 will also investigate correlations with performance on a non-word repetition task, which could be viewed as a test of either phonological short-term memory (thus testing the predictions of Gathercole & Baddeley, 1990) or phonological abilities, thus testing the hypotheses of Chiat (2001 – Phonological Mapping), Leonard (1998 - Surface) and Bishop (1994a).

2.3.2 Studies of verb learning and argument structure development in SLI

Several studies have concluded that children with SLI have difficulties learning verbs (Rice & Bode, 1993; Watkins, Rice & Moltz, 1993; Oetting et al., 1995; Conti-Ramsden & Jones, 1997) but the underlying reasons for this have been investigated in few studies. A study of the ability of children with SLI to learn novel transitive verbs during play sessions (Conti-Ramsden & Windfuhr, 2002) showed that they were able to learn the root meanings of verbs from observation and also to use them in sentences. During play sessions, the adult used the verbs in isolation, in transitive syntactic frames or with either the Subject or Object omitted. The children were more likely to use the syntactic frame used by the adult, suggesting they were using associative pairing mechanisms to pair the verb with the syntactic frame used by the adult. However, they did also express Agents or Patients as Subjects and Objects when the adult sentences did not include these, suggesting that they were able to use forward linking. Van der Lely (1994) also showed that children with SLI could use observational learning to the same extent as controls to infer the root meaning and thematic core of novel verbs and then use forward linking to produce the verb in an appropriate syntactic frame.

However, as discussed above, observation is unreliable for establishing the thematic cores of some verbs. Thus, it is important to establish whether the children with SLI can use syntactic bootstrapping (or reverse linking) to hypothesise possible thematic cores for new verbs or modify stored thematic cores for known verbs. Two studies provide evidence that children with SLI are aware of the links between syntactic frames and types of events. Oetting (1999) showed that they could relate transitive versus intransitive syntactic frames to causative versus unergative verbs and events as well as language controls. Hoff-Ginsberg et al. (1996) showed that when children with SLI were asked to enact sentences involving known verbs in syntactic frames with more or fewer arguments than the number of participants in the verb's thematic cores, they responded in a similar way to controls. That is, they tended to act 'frame compliantly', enacting an event which matched the number of participants in the syntactic frame rather than the thematic core of the verb.

The two studies described above show that children with SLI are sensitive to the number of syntactic arguments used, but do not directly test the children's ability to use reverse linking to identify the thematic cores of novel verbs purely from use of a syntactic frame, without reference to known verbs or possible events. This was investigated by van der Lely (1994) where children heard a sentence including a novel verb and had to act out a possible event for the sentence. The children with SLI performed significantly worse than the control children, although they were usually able to act out appropriate events involving the correct number of participants. This indicates that they were aware of some the links between syntactic frames and types of events. Their most frequent error was linking the referents of the NPs to the incorrect thematic roles, for example, giving a Patient role to the referent of the NP in the subject position, and an Agent role to the referent of the object position. Thus, it seems that while they were able to use the sentence to identify the correct number of participants and event type, they could not reliably use reverse linking to assign the correct thematic roles to the correct referents. These results were, in the main, replicated by O'Hara and Johnston (1997). However, their qualitative analysis of the errors showed a more systematic pattern than van der Lely's (1994) study (where errors appeared to be random). In O'Hara and Johnston's (1997) study, the children with SLI made more errors on the NPs appearing earlier in the sentence and the substituted objects shared semantic features with target lexemes.

Both studies also report that the children with SLI as a group had more difficulty with the locative than transitive sentences. In O'Hara and Johnson's study, they also had more difficulties with transitive sentences involving three arguments (co-ordinated subjects) than those with two arguments. This disproportionate difficulty with longer sentences and the non-random error patterns led them to suggest that the children with SLI failed the task due to processing difficulties. They claim that the task is particularly complex because the whole set of arguments have to be processed together for reverse linking rather than one at a time as is possible with forward linking. This leads to a greater processing load and when this is increased further, as with longer sentences, the children 'lose' information about which referents were involved and/or which referent was to play which role.

However, in van der Lely's (1994) study, the individual analyses showed a different picture: despite the worse performance of the group as a whole on locative sentences, two out of six individuals performed better on the locative sentences. Locative and transitive sentences do not only differ in length, where the locative sentences are longer and therefore arguably involve a higher processing and memory load; they also differ in terms of how reliably reverse linking can predict the thematic core of the verb. The thematic core of the verb is *more* predictable from a locative sentence (transitive + oblique object with 'to') than a transitive sentence (as shown in Figure 2.3): the locative argument structure links to only one thematic core, whereas the transitive structure links to several. Thus, reverse linking is actually more complex for transitive than locative sentences. It is therefore possible that the two children who performed reliably with the locatives but not the transitives, were able to apply reverse linking but only where its outcome is predictable. The other four children had difficulty interpreting the sentences accurately for both the locatives and transitives, but particularly the locatives. This indicates a difficulty using reverse linking, however, this could arise for one of two reasons. The task could exceed their processing capacity and hence they forget which items occurred in which position in the sentence as suggested by O'Hara and Johnson. Alternatively, van der Lely suggests they have a deficit with the syntactic representation which specifies the relationship between the verb and the argument positions. Without such a representation, they would be unable to reliably identify the Subject, Object and oblique Object and therefore cannot begin to use reverse linking to identify the correct semantic representation. In both cases, children would be unable to apply reverse linking, either because they cannot identify the grammatical roles of the noun phrases in the first place, or because they forget what those roles are due to the processing demands of the task. The tasks in the two studies do not allow us to distinguish between these two possibilities and further studies which look in detail at the error patterns of individual children are needed. It is also possible that the underlying reason for difficulties with reverse linking varies between children.

If, as both of these studies indicate, children with SLI have difficulties using reverse linking (whether because of syntactic or processing difficulties), they would be predicted to make errors with those verbs which rely on the use of reverse linking to establish their action tier (such as *pay, buy, sell, fill, cover*). Thus, we would predict that children with SLI would hypothesise the incorrect thematic core for some verbs (particularly change of state verbs where reverse linking is required to identify the correct thematic core) and produce argument structure errors such as those reported by Gropen (1991b) and Bowerman (1982) (e.g., "Can I fill some salt into the bear?"). This hypothesis has not been investigated in detail for children with SLI, although the child described in Chiat (2000) had difficulties with *buy* and *sell*. Also, the author has collected examples of spontaneous speech errors with these verbs in the course of her clinical work with children with SLI:

- "Mum bought a jacket from the children" (describing a situation where the children bought a jacket and gave it to mum)
- "The girl is paying the balloon" (describing a picture of a girl buying a balloon from a man)
- "I sold a rubber at the shop" (child bought a rubber)
- "The boy filled the milk into the bowl"
- "The boy filled the milk on the bottle"
- "You can cover it on a sandwich" (describing cling film)

Therefore, the study in Chapter 5 will include a comparison of the ability of children with SLI to use the correct argument structure with change of state versus change of location verbs and also compare their performance with language and age controls. Poorer performance with change of state verbs could indicate a difficulty with reverse linking in the presence of an intact ability to use forward linking.

2.3.3 Alternations

Few studies have investigated the abilities of children with SLI to use (and restrict the use of) verb alternations. Thordardottir & Weismer (2002) found that children with SLI used fewer verb alternations in spontaneous speech than age controls but were no different from language controls. However, their definition of alternations differs from that used here as they include the use of verbs with and without optional arguments as a type of alternation. Two elicitation studies have considered use of the causative alternation. One found children with SLI did not differ from language or age controls in their ability to use (or restrict overgeneralisation of) the causative alternation (Loeb, Pye, Richardson & Redmond, 1998), while another (Schelletter, Sinka, Fletcher & Ingham, 1998) found that the ability to use the causative alternation varied with the ability to use the past tense. Those children with SLI who had difficulties using the past tense used the causative alternation significantly less than their age controls and showed a tendency to use it less than their language controls. However, those with fewer difficulties using the past tense used the causative alternation more than their language controls, almost at the level of their age controls. Schelletter et al. (1998) also investigated the use of the locative alternation, but the numbers were too small to carry out any comparisons of the performance of the different groups. No other studies were found which have investigated the use of the locative alternation in children with SLI.

As far as the dative alternation is concerned, Thordardottir & Weismer (2002) found that the biggest difference from controls in the spontaneous speech of the children with SLI was their limited use of the ditransitive construction. However, a study of the *comprehension* of this construction found no difference between children with SLI and their language controls (van der Lely & Harris, 1990).

2.3.4 Obligatory arguments

Studies of spontaneous speech have found that children with SLI omit very few obligatory arguments (King & Fletcher, 1993; Rice & Bode, 1993; Thordardottir & Weismer, 2002). However, while the number of omissions has in general not been found to differ from language controls (King & Fletcher, 1993; Thordardottir & Weismer, 2002), they have been found to omit arguments on a wider range of verbs (King & Fletcher, 1993) and to omit more subjects with unaccusative verbs (Grela & Leonard, 1997). They also omit more obligatory arguments than age controls (Thordardottir & Weismer, 2002).

Elicitation studies have not focused directly on omission of obligatory arguments by children with SLI. However, in one study focusing on verb particles and prepositions (Watkins & Rice, 1991), children with SLI omitted more objects and verbs than language or age controls. Conversely, in a judgement task, Gopnik & Crago (1991) found that their subjects from the KE family had no difficulties identifying and correcting the addition or omission of obligatory arguments.

2.3.5 Summary of argument structure in children with SLI

Very few studies have investigated the ability of children with SLI to learn and use argument structure accurately, but they do indicate some difficulties in this area (contra those theories of SLI which focus only on morpho-syntax). Studies of the use of normal learning mechanisms indicate that children with SLI have no difficulties using observational learning and forward linking but they do appear to have difficulty using reverse linking in isolation. This favours theories of SLI which propose either processing/memory difficulties or deficient syntactic representations and disfavours the phonological mapping hypothesis which would also predict difficulties with observational learning and forward linking. The consequences of a difficulty with reverse linking have not been examined, but it would be predicted to lead to more difficulties with change of state verbs (such as *fill* and *cover*) because use of observation in isolation could lead children with SLI to hypothesise the incorrect thematic core. Thus, Chapter 5 will consider the performance of children with SLI on change of state versus change of location verbs and compare their performance with that of age and language controls.

Only three studies consider the ability of children with SLI to use verb alternations and only the causative alternation has been studied in any detail (with conflicting results). While one study has compared use of the ditransitive construction by children with SLI and controls, it did not directly investigate the children's preferences in choosing between the two syntactic frames. The locative alternation has not been systematically investigated in any study. Therefore, Chapter 5 will investigate the use of all three alternations by children with SLI and again compare their performance with that of language and age-matched controls.

Studies of the use or omission of obligatory arguments by children with SLI have only investigated spontaneous speech and have indicated some differences from controls. Chapter 5 will use an elicitation study to investigate the omission of obligatory arguments in more detail.

Several theories of SLI could account for difficulties with verb argument structure, but they differ in their predictions of the relationship between argument structure and other areas of language. The RDDR hypothesis predicts a relationship between argument structure and syntactic complexity measures, while the CGC also predicts correlations with morphological and phonological complexity measures. The processing theories of SLI predict correlations with measures of phonology, working or short-term memory. Therefore, Chapter 5 will also consider correlations of performance on a test of argument structure with measures tapping vocabulary knowledge (BPVS) and those relying on good syntactic (TROG, Formulated Sentences), morphological (VATT) and phonological abilities (TOPhS). The BPVS, TROG, Formulated Sentences and VATT are described in Chapter 3, the argument structure test in Chapter 4 and the TOPhS in Chapter 6. The TOPhS was designed to be a test of phonological structural and prosodic complexity using a non-word repetition paradigm. However, non-word repetition tests have also been used in the past as a measure of working or phonological short-term memory, in particular because performance usually declines for longer words. Therefore, in Chapter 6, I will analyse the factors underlying performance on the TOPhS and aim to establish whether performance is affected more by length or complexity.

2.4 Summary of the chapter

In this chapter, I first gave a theoretical background to the study of verb argument structure, focussing on two lexical accounts and one construction account. A particular focus of discussion was on verb alternations, where I aimed to provide a theoretical framework for the subsequent discussions of how children learn to use (and restrict the use of) these alternations. The second section discussed the development of aspects of verb meaning and knowledge regarding obligatory arguments and reviewed studies investigating these areas in typically developing children. The third section considered the implications of theories of SLI for the development of argument structure and reviewed studies investigating this area in children with SLI.

Investigations of argument structure in typical development and SLI have followed different paths. While the learning mechanisms involved in argument structure acquisition have been investigated to a certain extent in both populations, other areas of argument structure have been investigated in only one population. Studies with typically developing children have focused on the overgeneralisation of alternations but not on the use of alternations with alternating verbs. Omission of obligatory arguments has also received scant attention. Studies of children with SLI in contrast, have focused on omissions of obligatory arguments and to a certain degree on the use of the causative and dative alternations, but have not considered the locative alternation or its overgeneralisation.

2.5 Investigations of argument structure in this thesis

This thesis aims to investigate the use of argument structure in secondary school-aged children with SLI (aged 11-16 years), to identify those areas (if any) where they have more difficulties than would be expected for their age, vocabulary levels or general grammatical abilities and then compare the effectiveness of two methods of intervention for improving their performance in these areas. Chapter 3 will describe the participants in Part 1 of this thesis as well as the statistical tests and methods used throughout the thesis. Older children with SLI were chosen because very few intervention studies have been carried out with this age group (see Chapter 8) and the author had noted in her clinical work with this age group that they appeared to have difficulties with argument structure. However, before carrying out an intervention study (Chapter 9) it was necessary to establish whether the children with SLI had more difficulties with argument structure than would be predicted from their age and/or language levels (Chapter 5). However, in order to be able to interpret any such findings, it was also necessary to consider first the typical development of the areas of argument structure under investigation (Chapter 4). Chapters 4 and 5 will investigate the abilities of typically developing children and children with SLI to use argument structure alternations with a variety of verbs. In addition, I will investigate their knowledge of whether arguments with a range of verbs are obligatory or not and whether this is related to verb frequency.

Chapter 5 aims to establish whether children with SLI have more difficulties than typically developing children and will therefore compare the performance of children with SLI with that of the typically developing children. Because children with SLI are heterogeneous, their controls will be individually matched to them on age or language level. This individual matching will enable more precise hypotheses to be formulated regarding the mechanisms which may contribute to any difficulties experienced by the children with SLI. However, in order to interpret these hypotheses, it is important to establish first how argument structure develops in typically developing children and teenagers. The groups of typically developing children which result from the method of matching in Chapter 5 have no independent validity as they are grouped purely with reference to the SLI group, and cannot therefore be used to indicate typical development. Thus, in Chapter 4, the control children are simply split by age into two groups.

The methods used in Chapters 4 and 5 are identical and consist of a verb video test which will be described in detail in Chapter 4. The results sections of Chapters 4 and 5 will follow the same format to enable comparison across chapters. First, I will consider the overall change in ability to use argument structure accurately with age and consider the relationship between other language measures and argument structure. Then, I will investigate any differences between change of state and change of location verbs. If children have more difficulties with change of state verbs, this could be due either to a difficulty with reverse linking or to overgeneralisation of the locative alternation. The difference between these two hypotheses would be indicated by the (in)consistency of the errors, hence I will analyse the error patterns of individual children. Next, I will investigate use of the dative and locative alternations with verbs which do alternate and preferences for particular syntactic frames, both in general and for individual verbs. For the causative alternation, I consider both production and judgement of the two syntactic frames of the alternation and aim to establish whether the children have knowledge of detransitivisation, which Levin and Rappaport Hovav (1995) claim is the primary process underlying this alternation. Correlations will also be carried out to establish any relationship between age, performance IQ, general language abilities (vocabulary and grammar) and the use of the causative alternation. The final section of each chapter will investigate the children's ability to use obligatory arguments and whether these abilities are related to verb frequency.

The results of Chapters 4 and 5 will indicate which areas of argument structure are particularly difficult for children with SLI compared to controls and how these areas relate to other language abilities. The conclusions drawn from these chapters will then be tested in an intervention study (in Chapter 9), which will aim to establish whether argument structure abilities can be improved in secondary school-aged children with SLI and which method of intervention is most effective in achieving this goal.

CHAPTER 3 PARTICIPANTS (FOR PART 1), PUBLISHED TESTS AND STATISTICAL METHODS

3.1 Participant selection and tests

3.1.1 Overview of the participants

Part 1 of this thesis focuses mainly on 15 children with SLI who all attend the specialist residential school where the author works as a Specialist Speech and Language Therapist. These children were individually matched on receptive vocabulary, grammar and age, to 45 typically developing children who acted as controls. The typically developing children were recruited from six mainstream schools in the same geographical region as the SLI school. Consent and information forms were sent to parents of children whom staff felt were likely to meet the criteria given below. The children were all tested on an individual basis in a quiet room in the familiar surroundings of their own school.

3.1.2 Participants with SLI

In order to be able to make theoretical claims about the possible underlying causes of any difficulties on the experimental tests, strict criteria were used for selecting the children with SLI: they had difficulties with both receptive and expressive language (at least –1.5 SD below the mean) as measured on the *Clinical Evaluation of Language Fundamentals-3 (CELF-3)* (Semel, Wiig & Secord, 1995) (see section 3.1.4.1), but typical non-verbal performance abilities (not more than –1SD below the mean) as measured on the *British Ability Scales-II (BAS-II)* (Elliot, Smith & McCulloch, 1996) (see section 3.1.4.2). In order to have access to the children for the duration of the study, children in the last 2 years at the SLI school at the start of the project were excluded. Therefore, all children in the SLI school who were in Key Stages 2 and 3 (aged 7-14 years) were considered as possible participants although information and consent forms were only sent to parents whose children met the following criteria:

- No hearing impairment
- Intelligible spontaneous speech
- No neurological dysfunction
- No structural abnormalities (e.g., cleft palate)
- No diagnosis of autism or Asperger's syndrome

All children whose parents returned a consent form were seen on an individual basis and tested on standardised tests to screen language levels and performance IQ (described below) and fifteen children with SLI who met the criteria for the study were identified. They were aged 11;0 – 14;11 years; 3 girls and 12 boys. Their details are given in Appendix A.

3.1.3 Typically developing controls

All control children were required to have both language abilities and performance IQ within normal limits (not below –1SD)[4]. Performance IQ was measured in the same way as for the children with SLI, using the mean of Matrices and Pattern Construction from the BAS-II. The tests used to measure language were the Formulated Sentences subtest of the CELF-3, the *British Picture Vocabulary Scale-II (BPVS)* (Dunn, Dunn, Whetton & Burley, 1997) and the *Test of Reception of Grammar (TROG)* (Bishop, 1989). See section 3.1.4 for a description of all published tests used in this thesis.

Three control groups were identified, one matched on age and two on language measures. All controls were individually matched to a child with SLI. The age controls (11;2 to 14;10 years) were aged within two months of their matched child with SLI and scored within one standard deviation on the BAS-II (performance IQ). Like the SLI group, this group included 3 girls and 12 boys, but the children were not individually matched on gender. The language controls (5;4 –12;2 years, 15 girls and 15 boys) were individually matched to the children with SLI on the basis of performance IQ (within one standard deviation) and either the BPVS ('BPVS controls': raw score within 3 points) or the TROG ('TROG controls': matched on exact raw score). They were also required to score within the normal range for their age (i.e., not more than 1 SD above or below the mean) for the test on which they were matched to the children with SLI.

Chapter 4 includes 10 adult participants aged between 25 and 70 years as a comparison for the typically developing children. These are friends and family of the author who were aware of the general purposes of the study but unfamiliar with its precise hypotheses. All had a university education but none had any specific training in linguistics or psychology.

[4] One age control achieved a z-score of –1.15 on the BAS, but showed no language difficulties, was matched to the child with SLI with the lowest z-score (-0.95) on the BAS and was exactly the same age; he was therefore considered to provide a good match.

3.1.4 Standardised and non-standardised assessments

3.1.4.1 Clinical Evaluation of Language Fundamentals (CELF-3 UK)

The children with SLI were tested on all the subtests for older children on the CELF-3. These include three subtests tapping receptive language and three tapping expressive language. The receptive language tests are:

- Concepts and Directions – the child responds to an instruction involving a series of black and white shapes. The instructions increase in length and complexity and also include concepts such as 'all', 'before', 'to the left of', 'first', 'second', 'next to'.
- Word Classes – the child listens to three or four words and decides which two of the words 'go together', e.g., 'road, teacher, biscuit, school'.
- Semantic Relationships – the child completes a sentence such as 'books are heavier than ....' using two of four options which are listed in a stimulus book (e.g., TVs, feathers, chairs, letters). Because many of the children with SLI have literacy difficulties, the tester read out the answers before giving the stimulus and then read out the answers again, while pointing at them.

The expressive language tests are:

- Formulated Sentences – the child is shown a stimulus picture and given a word which they have to use in a sentence to describe the picture. Many of the words are subordinators such as 'because', 'if', 'whenever'.
- Recalling Sentences – the child repeats sentences of increasing length and complexity, ranging from 'did the girl catch the netball?' to 'the teacher in the room next door promised to water the plants during the summer holidays'.
- Sentence Assembly – the child creates two sentences from a series of words or phrases, e.g., 'lost', 'is', 'the baby's' 'ball'. These require a variety of structures such as: questions, coordination, the passive and ditransitive constructions.

The raw score for each subtest can be converted to a standard score. Composite standard scores for both receptive and expressive language are calculated from the sum of the three subtest standard scores. These give a measure of the child's overall receptive and expressive language abilities. These can also be combined to give a 'Total Language' score. The subtests in the CELF-3 are non-specific and test a wide range of linguistic abilities, however, it is standardised on a large number of children in the UK and for this reason is widely used for diagnosing language impairment. The criteria used in this study were that both the receptive and expressive composite standard scores should be at or below -1.5 standard deviations. Thus, only children with severe and global language impairments were included in the study (the highest Total Language score was -1.7 standard deviations). In addition, they were all required to have a score on the Formulated sentences subtest of 6 or less (z-score of $\leq$-1.3). This additional criterion was included because this test was used to rule out expressive language impairment in the control children (see below).

3.1.4.2 British Ability Scales II (BAS-II)

In order to ensure that the children's difficulties were specific to language and not due to any other more general learning difficulties, a measure of their performance IQ (i.e., non-verbal IQ) was required. The BAS-II consists of four non-verbal subtests: two involving spatial abilities (Pattern Construction and Recall of Designs) and two involving non-verbal reasoning (Matrices and Quantitative Reasoning):

- Pattern Construction – the child sees a visual pattern and constructs the same pattern using blocks with different coloured faces (all yellow or black, half yellow and black, diagonal versus horizontal).
- Recall of Designs – the child views a line drawing for a few seconds and then reproduces the design without looking at the original. The scoring system demands very precise reproductions of designs and provides very little room for error.
- Matrices – the child studies a pattern with one element missing and deduces which element out of a choice of six best completes the pattern.
- Quantitative Reasoning – for children over the age of 11 years, this test involves viewing two pairs of numbers and half a pair (e.g., 3 6; 5 10; 2 _). The task requires working out the value of the number which is missing following the same pattern as in the first two pairs.

While these tests are designed to tap the children's cognitive abilities irrespective of language, some involve skills which are known to be weak in children with SLI. Donlan (1993) found links between poor mathematical abilities and language impairment, probably because some aspects of mathematics rely heavily on language. Hence in this study, the Quantitative Reasoning subtest was not used. Poor fine motor skills have also been reported in some children with SLI (Hill, 2001); this would particularly affect performance on Recall of Designs, which was therefore also omitted. Poor fine motor skills could also affect Pattern Construction, however, children with

SLI have been found to be unimpaired on this task (Powell & Bishop, 1992). Therefore the Pattern Construction and Matrices subtests were used. An averaged score cannot be obtained for these two subtests from the BAS as they belong to different 'clusters' – spatial and non-verbal reasoning. Therefore I constructed a single score by taking the average of the two individual T scores and converted them into a z-score: (T-50)/10. Any child with a z-score <-1 on this averaged score was excluded from the study.

3.1.4.3 British Picture Vocabulary Scales – II (BPVS-II)

The BPVS is a multiple-choice vocabulary comprehension test where the child selects a picture from four to match the word spoken by the tester. The targets include verbs, adjectives and nouns and the test covers vocabulary from 2½ years to adulthood.

3.1.4.4 Test of Reception of Grammar (TROG)

The TROG is a multiple-choice sentence comprehension test in which the child selects a picture from four to match a sentence spoken by the tester. All items use simple vocabulary but grammatical complexity increases as the test proceeds. Each of the 20 sentence types is tested in 'blocks' of four similar items. A block is passed only if the child responds to all four items correctly.

3.1.4.5 Verb Agreement and Tense Test (VATT) (van der Lely, 2000)

The VATT considers a child's ability to use tense and agreement for low and high frequency, regular and irregular verbs. The children have to complete sentences to describe picture stimuli in the present (e.g., *every day Woody slams the door*) and past tense (e.g., *yesterday Woody slammed the door*).

3.1.4.6 The Test of Phonological Structure(TOPhS) (Harris & van der Lely, 1999)

The TOPhS tests the children's ability to repeat non-words of increasing phonological complexity. It will be described in detail in Chapter 6.

3.2 Statistical methods

All data were analysed using the statistical package SPSS v11.0. Statistical significance was assumed at $p \leq 0.05$ unless otherwise stated. Before applying any statistical tests, all data were explored in order to establish whether they met assumptions of normality. The Shapiro-Wilk test was used, which Field (2000) states is more accurate than the other test for normality available in SPSS (Kolmogorov-Smirnov). If the data deviated from normality as shown by a p-value on the Shapiro-

Wilk test of <0.05, the distribution of the data were considered using histograms. In this thesis, the main reasons for deviations from normality were ceiling or floor effects in by-items analyses. In these cases, transformations were attempted to normalise the data, but the ceiling/floor effects were usually too strong for these to be sufficiently effective. In these cases, non-parametric statistics were used. In Chapter 6, deviation from normality in the SLI group was due to a bimodal distribution and in this case the group was split into two.

3.2.1 Group comparisons

3.2.1.1 Parametric methods

Group comparisons with parametric data were analysed with ANOVAs or t-tests. When comparing groups of children, I used independent measures analyses. Equality of variance was measured using Levene's test. Where this was significant and group sizes were unequal, I either used Welch's correction (for one-way ANOVAs) or if the data also deviated from normality, non-parametric statistics. When looking within groups at particular features of the stimuli, I used repeated measures tests. Where sphericity was violated, I used Greenhouse Geisser's correction as recommended by Field (2000). For all ANOVAs, I quote the effect size η^2; this is a measure of the amount of variance which can be accounted for by each factor and is calculated as the Sum of Squares (treatment) divided by the Sum of Squares (total). All results are quoted in the form: (F (degrees of freedom), p, η^2).

For post-hoc comparisons I used the conservative Bonferroni correction. In Chapter 5, I used planned comparisons (i.e., did not consider all combinations of pairs) because I was only interested in comparing the SLI group with each of the control groups. In this case, the relevant t-tests were done in SPSS without applying a Bonferroni correction but the value at which p was taken to be significant was reduced by dividing 0.05 by the number of comparisons – thus providing a manual Bonferroni correction.

For all t-tests I quote the effect size **d**. This indicates the number of standard deviations by which the two samples differ (or for a one-tailed test by which the sample differs from a specified value). This is calculated by subtracting the two sample scores from each other and dividing by their pooled standard deviation. The pooled standard deviation is calculated from the following formula[5]:

[5] All formulae quoted in this chapter are from Howell (1997)

$$\sigma_{pooled} = \sqrt{\frac{(n_1 - 1)\sigma_1^2 + (n_2 - 1)\sigma_2^2}{n_1 + n_2 - 2}}$$

where n_1 and n_2 are the number of data points in groups 1 and 2 respectively and σ_1 and σ_2 are the standard deviations of each group. For all t-tests I will quote: (t (degrees of freedom), p, d).

3.2.1.2 Non-parametric methods

When assumptions of normality were violated, non-parametric tests were used. For independent samples, I used the Kruskal-Wallis test for more than 2 groups and Wilcoxon's signed ranks test (called 'Mann-Whitney' in SPSS) for 2 groups. For related samples, I used Friedman's test for more than 2 groups and Wilcoxon's matched samples tests for 2 groups. For all of these, I used the 'Monte Carlo estimate' available in SPSS which estimates the significance without using the normal approximation for the statistic distribution. For the Friedman and Kruskal Wallis tests, I quote: (χ^2(degrees of freedom), p-value). For the Wilcoxon signed ranks test I quote: (W=smallest sum of ranks, n_1=number in smaller group, n_2=number in larger group, p). For the Wilcoxon matched samples test I quote: (T=the smallest sum of ranks, n=the number of data points which are not tied, p).

In order to explain how I analysed main effects and interactions with non-parametric statistics, I will refer to the graph in Figure 3.1 which involves hypothetical data (but similar to those in Chapter 4). This shows the performance of Groups 1, 2 and 3 ('Average' shows the average of the three groups) on A vs B verbs. It shows their mean scores on both groups of verbs and also a subtracted score: A-B. Non-parametric statistics are used because of the ceiling effect on the 'A verbs' for all three groups. The main effect of verb is analysed using a Wilcoxon matched samples test (as all participants were tested on both A and B verbs) on the Average scores for A versus B verbs (i.e., the right-most panel of Figure 3.1). This asks whether the A verbs (black) are equal to the B verbs (white), or alternatively whether the A-B score (grey) is equal to zero. The main effect of group is analysed by comparing the mean scores (striped) for Group 1 vs Group 2 vs Group 3 using Kruskal-Wallis and Wilcoxon signed ranks tests.

The interaction between Group and Verb is calculated using the subtracted scores (grey), as this shows for each group the difference in performance between the A and B verbs. If there is no interaction, the groups will have similar subtracted scores, but if there is an interaction, the subtracted scores will differ. This can be analysed using a

Kruskal-Wallis and Wilcoxon signed ranks tests. Because the same participants are used in all conditions, all interactions with two levels (e.g., A and B verbs) can be measured using subtracted scores. If the interaction is significant, the simple effects of verb type (A vs B) can be analysed by comparing A and B verbs for each group using a Wilcoxon matched samples test (i.e., is A-B equal to zero).

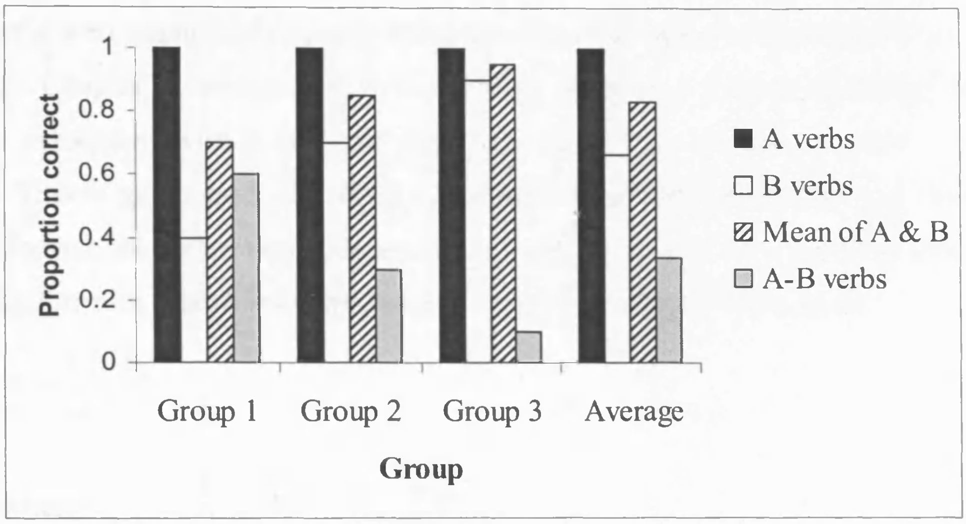


Figure 3.1: Hypothetical data involving interaction between verb type and group

3.2.2 Correlations and regression

When analysing data for correlations, I used Pearson's correlation for normally distributed data, otherwise I used Spearman's rank correlation. The choice as to whether to use a one-tailed or two-tailed test depended on the *a-priori* research question. For example if the question concerned whether performance on a particular measure improved with age, only a one-tailed test was used as any decrease with age would not be of interest. In some analyses it was of interest whether two variables correlated after the effects of a third variable had been removed. In these cases, I carried out partial correlations (correlations between the two sets of residuals formed after regressing the variables of interest on the third variable). These give a measure of the shared variance between two variables after removing the variance accounted for by the third variable. In some instances it was of interest whether two correlations differed from each other. In such cases, I used the method described by Howell (1997). For each value of r, it was necessary to calculate r', which was given by the following formula:

$$r' = 0.5\log_e \frac{|1+r|}{|1-r|}$$

Then, using the values of r' it was possible to calculate a z-score using the following formula:

$$z = \frac{r_1' - r_2'}{\sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}}$$

Values of p were established by consulting the statistical tables in Howell (1997).

In Chapter 6, analyses were carried out where the amount of change in one variable associated with a one-unit difference in another variable was the focus of interest. This is given by *b*, the slope of the regression line between the two variables. The difference between two independent values of *b*, can be calculated using the following formula, which is distributed as *t* on n_1+n_2-4 degrees of freedom:

$$t = \frac{b_1 - b_2}{s_{b_1 - b_2}}$$

where $s_{b_1-b_2} = \sqrt{\frac{s^2_{Y \cdot X_1}}{s^2_{X_1}(n_1 - 1)} + \frac{s^2_{Y \cdot X_2}}{s^2_{X_2}(n_2 - 1)}}$

and s^2_X is the variance of the predictor variable and $s^2_{Y.X}$ is the variance of Y not explained by the regression (i.e., the variance of the residual).

3.3 Comparisons between children with SLI and controls on selection tests

A summary of the children's scores on the language and cognitive measures used for selection are shown in Table 3.1 and the individual data in Appendices A and B. One-way ANOVAs and post-hoc Bonferroni corrected t-tests (or non-parametric equivalents where applicable) were carried out with Group as the between-subjects variable. As expected, the children with SLI scored significantly lower than all control groups on the z-scores of the language tests ($p<0.001$) but the three control groups did not differ from each other on any of these measures ($p>0.17$). The SLI group also scored significantly lower than all control groups on raw score of the Formulated Sentences subtest of the CELF-3 ($p<0.001$, $d>1.75$), the age controls scored higher than the language controls ($p<0.007$, $d>1.3$) who did not differ from each other ($p=1.0$, $d=0.24$). The groups showed no difference in their performance IQ ($F(3,56)=2.14$, $p=0.11$, $\eta^2=0.10$).

In order to validate the matching procedures, the groups were compared on age and also raw scores of the language tests used for matching. These showed a significant effect of age ($F(3,56)=51.18$, $p<0.001$, $\eta^2=0.73$) where the children with SLI did not differ in age from the age controls ($p=1.0$, $d=0.004$), but differed significantly from both TROG ($p<0.001$, $d=3.35$) and BPVS controls ($p<0.001$, $d=3.03$). The latter two groups did not differ from each other ($p=1.0$, $d=0.3$), but did differ from the age controls (TROG: $p<0.001$, $d=3.34$, BPVS: $p<0.001$, $d=3.03$).

Table 3.1: Summary of participant details for children with SLI and matched control groups: Mean, (standard deviation) and range

		SLI	TROG controls	BPVS controls	Age controls
Age (in months)		157.07 *(14.88)*	98.93 *(19.72)*	104.33 *(19.51)*	157.13 *(14.73)*
		132 to 179	64 to 135	70 to 146	135 to 178
Performance IQ (BAS-II)		-0.04 *(0.82)*	0.33 *(0.60)*	0.53 *(0.68)*	0.06 *(0.66)*
		-0.95 to 1.55	-0.6 to 1.25	-0.55 to 1.95	-1.15 to 1.6
BPVS	z-score	-1.69 *(0.62)*	0.30 *(0.72)*	0.28 *(0.32)*	0.44 *(1.06)*
		-2.53 to -0.33	-0.93 to 1.60	-0.33 to 0.73	-1.00 to 3.40
	raw score	91.07 *(14.24)*	87.00 *(16.17)*	90.87 *(13.84)*	121.87 *(13.45)*
		63 to 115	58 to 120	65 to 112	99 to 149
TROG	z-score	-1.21 *(0.63)*	-0.17 *(0.60)*	0.46 *(0.95)*	0.31 *(0.84)*
		-2.47 to -0.13	-0.93 to 0.73	-0.60 to 2.00	-0.53 to 2.13
	raw score	15.40 *(2.32)*	15.40 *(2.32)*	17.00 *(1.69)*	18.33 *(0.90)*
		9 to 18	9 to 18	15 to 19	17 to 20
CELF-3 z-scores	Receptive Language	-2.14 *(0.33)*	n/a	n/a	n/a
		-2.40 to -1.60	n/a	n/a	n/a
	Expressive Language	-2.2 *(0.33)*	n/a	n/a	n/a
		-2.40 to -1.53	n/a	n/a	n/a
	Total Language	-2.30 *(0.23)*	n/a	n/a	n/a
		-2.47 to -1.67	n/a	n/a	n/a
Formulated Sentences	z-score	-2.13 *(0.41)*	-0.03 *(0.56)*	0.07 *(0.79)*	0.33 *(0.93)*
		-2.33 to -1.33	-0.67 to 0.67	-1.00 to 1.33	-1.00 to 2.00
	raw score	20.2 *(7.37)*	30.64 *(5.20)*	31.07 *(6.73)*	38.60 *(3.94)*
		5 to 30	21 to 38	19 to 43	33 to 44

The four groups differed significantly on the BPVS raw score ($F(3,56)=18.874$, $p<0.001$, $\eta^2=0.50$). Post-hoc tests showed the children with SLI did not differ from either their BPVS ($p=1.0$, $d=0.01$) or TROG controls ($p=1.0$, $d=0.28$) but scored significantly lower than their age controls ($p<0.001$, $d=2.13$), as did both the TROG ($p<0.001$, $d=2.41$) and BPVS controls ($p<0.001$, $d=2.15$) who did not differ from each other ($p=1.0$, $d=0.27$).

The four groups also differed significantly on the TROG raw score ($\chi^2(3)=23.46$, $p<0.001$). Post-hoc tests showed the children with SLI did not differ from either their

TROG ($W=232.5$, $n_1=15$, $n_2=15$, $p=1.0$) or BPVS controls ($W=74.5$, $n_1=15$, $n_2=15$, $p=0.11$), but did differ from their age controls ($W=130$, $n_1=15$, $n_2=15$, $p<0.001$). The TROG controls differed from the age controls ($W=130$, $n_1=15$, $n_2=15$, $p<0.001$) while the BPVS controls did not ($W=185.9$, $n_1=15$, $n_2=15$, $p=0.05$, as the Bonferroni corrected significance value is 0.05/6=0.008). Again, the TROG and BPVS controls did not differ significantly from each other ($W=194.5$, $n_1=15$, $n_2=15$, $p=0.11$).

Thus, in summary, the children with SLI matched their control groups very closely ($p=1.0$, $d<0.01$) on the relevant measures, indicating the effectiveness of individual matching. The age controls had higher BPVS and TROG scores than the children with SLI and the language controls. While the two language control groups did not differ significantly from each other on the language tests or age, the BPVS group were slightly older and had slightly higher raw scores on both language tests. The three results chapters of Part 1 of this thesis (Chapters 4, 5 and 6) group the typically developing children in different ways according to the purpose of each chapter. This flexibility was only possible because of the use of individual matching of the typically developing children to the children with SLI.

Chapter 4 investigates the ability of the typically developing children to use argument structure and compares their performance to that of a group of adults. For this chapter, they are not split into the three control groups as these groups were defined in relation to the children with SLI and have no independent validity (as shown by their overlap in terms of both age and language ability). Thus, they are split by age into two groups and compared with the adult group.

Chapter 5 investigates the ability of the children with SLI to use argument structure. Because argument structure is at the interface between semantics and syntax and is learned through experience of language and situations, it is of interest whether children with SLI use argument structure in a similar way to controls with broadly similar levels of knowledge of semantics (BPVS controls) or syntax (TROG controls) or children of the same age (age controls), thus each of these pairwise comparisons are carried out. Because the control groups have no independent validity, their performance is not compared to each other but only to the children with SLI.

Chapter 6 investigates the impact of phonological complexity and length on the performance of the children on a test of non-word repetition and the relationship of this to other areas of language. The children with SLI show a bimodal distribution and thus are split into two groups (SLI-high and SLI-low). Because the controls were individually matched to the children with SLI, it was possible to split the control groups into those which match the SLI-high versus SLI-low group and carry out comparisons of each of the SLI groups with their three control groups.

CHAPTER 4 ACQUISITION OF ARGUMENT STRUCTURE IN TYPICALLY DEVELOPING CHILDREN

4.1 Introduction and aims of chapter

This chapter aims to address some of the gaps in the literature revealed by the review of typical development of argument structure (in Chapter 2, section 2.2). When summarising the proposed mechanisms involved in the acquisition of argument structure, I concluded that the most effective learning of verb meaning and argument structure results from parallel use of semantic cues from observation and syntactic cues, particularly for learning verbs whose meanings are less transparent to observation, including change of state verbs (such as *fill* and *cover*). I hypothesised that young children may not use syntactic cues in learning such verbs and this could lead to an incorrectly stored thematic core and hence to consistent use of the incorrect syntactic frame with these verbs. Evidence for such errors is provided by Bowerman (1982) for the verb *fill* by one of her daughters. Gropen (1991b) also provides evidence of errors with change of state verbs in a larger group of children, but does not analyse the consistency of these errors in individual children. Inconsistent errors with such verbs could arise from overgeneralisation of the locative alternation and would be predicted to occur later in development than consistent errors. Evidence for or against such a developmental hypothesis requires analysis of individual patterns of performance in order to establish whether such errors are consistent (limited use of syntactic bootstrapping) or inconsistent (overgeneralisation of the locative alternation) and whether the pattern of errors changes with age or language ability. In this chapter, I will therefore compare errors of choice of syntactic frame with change of state verbs versus change of location verbs in typically developing children and investigate individual patterns of performance.

Chapter 2 also highlighted the fact that the use of alternations with alternating verbs by typically developing children has received little attention; the majority of studies have focused on the overgeneralisation of alternations to non-alternating verbs. This chapter will therefore investigate children's developing ability to use verb alternations with alternating verbs. I will consider the three alternations discussed in Chapter 2: the locative, dative and causative alternations. I will aim to establish whether children are able to use both syntactic frames involved in the alternations, whether they have a preference for one syntactic frame (either over the alternation as a whole or for individual verbs) and whether their pattern of performance changes with age or language levels. I will investigate the causative alternation in particular detail in the light of Levin and Rappaport Hovav's (1995) hypothesis (see section 2.1.3) that this alternation is not a single alternation but involves three different processes: causativisation, detransitivisation and the use of verbs with two separate stored semantic representations. They claim that the majority of verbs undergoing the 'causative alternation' actually undergo detransitivisation rather than causativisation. However, the majority of studies investigating children's use of the causative alternation have considered only the process of causativisation. Therefore, in order to investigate whether their hypothesis accounts for children's performance, I will investigate the ability of children to use both the transitive and intransitive constructions with verbs which Levin and Rappaport Hovav hypothesise undergo detransitivisation.

Another gap in the literature regarding typically developing children is the lack of studies examining whether they omit obligatory arguments. This is important because several studies (discussed in section 2.3.4) have found that children with SLI omit obligatory arguments, but no developmental data have been published with which to compare these findings. I therefore aim to establish whether children do omit obligatory arguments and whether certain types of arguments are omitted more than others. I will also consider any possible relationship between omission of arguments and verb frequency as predicted by the hypothesis that children learn the obligatoriness of arguments statistically and /or through parental corrective feedback (see section 2.2.3).

4.2 Methods

4.2.1 Participants

The participants were the 45 (language and age) control children whose details are discussed in Chapter 3 and also 10 adults. The children ranged in age from 5;4 to 14;10 years. They were divided into two age groups using a median split, thereby resulting in a younger group of 22 children, mean age 7;9 (range: 5;4-9;5) and an older group of 23 children, mean age 12;2 (range: 9;7-14;10). The adults were aged 25-70 years and were friends and family of the author who were aware of the general purposes of the study but unaware of its precise hypotheses. None had any specific training in linguistics or psychology.

4.2.2 Argument structure production test

4.2.2.1 Materials

The production test consisted of 72 video scenes depicting 24 verbs (3 different scenes for each verb). The verbs were chosen to involve a range of argument structures: they require between one and three obligatory arguments and assign a variety of thematic roles to their arguments. The 24 verbs are shown in Table 4.1 together with the thematic roles of their Subjects and Objects. Considering the Subject first, the verbs were divided into three groups: 1) those with an obligatory Agent in the subject position, 2) verbs where the Subject is not an Agent but is a kind of Theme or Patient (unaccusative verbs) and 3) those which can alternate between an Agent and Theme/Patient (i.e., which can undergo the causative alternation). For the object position, the verbs were divided into five groups. The first group are obligatorily intransitive and hence do not permit an object. The others are all transitive verbs but are split into those where the object changes location, those where it changes state and those verbs which can undergo the locative and dative alternations.

Table 4.1: Linguistic features of verbs used in test

		Subject		
		Theme/Patient	Agent	Causative alternation
Object (if present)	No object (intransitive)	*bubble, fall*	*jump, laugh*	
	Change of location		*put, steal*	*hang, pour, roll, spill*
	Change of state		*build, rob*	*cover, fill, melt, open*
	Locative alternation		*sew, wipe, pack*	*empty, peel, spread*
	Dative alternation		*give, pass*	

Where a verb has more than one possible argument structure, the video scenes were designed to elicit these differing structures. For example, a verb such as *open* can undergo the causative alternation and hence can be used with either a transitive (*the lady is opening the door*) or intransitive construction (*the door is opening*). Therefore, one of the scenes for the verb *opening* shows a door opening for no obvious reason while the other two show transitive scenes such as a lady opening a door.

The scenes, possible answers and the number of obligatory arguments required for those answers are listed in Appendix C along with their verbal frequency (Brown, 1984), where available. Some scenes have more than one correct answer (i.e., for alternating verbs) and the minimum number of arguments may vary with these answers, for example, *he's wiping the table* requires two arguments whereas *he's wiping something off the table* requires three.

4.2.2.2 Procedure

The order of the video scenes was randomised but then checked by hand to ensure that there was a gap of at least two items between different scenes involving the same target verb. All participants watched the scenes in the same order. For each scene, the participant was shown the video clip once while the experimenter provided the target verb in the gerund: "this is *VERB*ing". The clip was then repeated and the participant was asked: "What is happening?" Four practice items at the beginning of the test were used to train the child to use the target verb in a complete sentence. Responses were recorded on a DAT tape recorder (TCD-D8) using an external Sony Electret condenser microphone and transcribed later.

4.2.2.3 Scoring

In the initial analysis, the children's responses were scored as either correct or incorrect. Sentences were only scored as correct if no obligatory arguments were omitted, if a target syntactic frame was used and if the transitivity of the sentence matched the transitivity of the scene. The adults' responses were used to judge whether arguments were omitted or not. This differs from previous studies where the authors presumably use their own intuitions (which could be unrepresentative of the intuitions of the adult population as a whole). Indeed, in this study, the adult data differed from the experimenter's intuitions in a few cases; for this reason experimenter intuitions were not used as a basis for the scoring system. Three of these differences in intuitions involved omissions of arguments which the experimenter had judged to be obligatory: at least two adults omitted prepositional phrases in the transitive version of *roll* e.g., *the man is rolling the ball (across the floor)* and the change of location form of *spread* e.g., *the man is spreading the butter (on the toast).* The third example was with the verb *build.* The task involved three 'building' scenes: *building a car, a tower* and *a house.* 5/10 adults omitted the object *house*, but none omitted either *car* or *tower*. This relates well to Rappaport Hovav and Levin's (1998) theory (discussed in Chapter 2, section 2.2.3) where 'prototypical' object arguments can be omitted. The prototypical object argument in the action of building is a *house* (but not a *car* or *tower*) so the adults omit the object only when it is a *house*. Therefore, in the scoring system, the object was marked as optional for the scene involving a *house* and as obligatory for the other scenes.

The other area in which the adult data differed from the experimenter's intuitions was with the verb *rob* where several adults made 'overgeneralisation errors'. One adult used it in the change of location construction for all three scenes (e.g., "the man is robbing the bag from the lady") and therefore seems to have an 'incorrectly' stored thematic core for this verb. A further five out of the ten adults used *rob* with the change of location construction for one of the three scenes suggesting they view this as an alternating verb. The remaining four adults used change of state construction exclusively (as per the text books!) Two out of ten adults also chose the change of location construction in the judgement task. Thus, this verb's status as a non-alternating change of state verb is brought into question and it was therefore excluded from all analyses.

More detailed coding systems were used for the investigation of particular areas of argument structure. These included recording use of the incorrect construction with change of location or change of state verbs, and for alternating verbs, logging which construction each child used for each scene and noting if any obligatory arguments were omitted.

All responses were transcribed and coded by the author. An independent scorer also coded the responses of four of the children (two with SLI and two controls). Inter-rater agreement was 97%.

4.2.3 Judgement test

This test had two purposes: 1) to investigate children's judgements of the causative alternation with verbs which detransitivise, and 2) to investigate their judgements of change of state and location verbs.

4.2.3.1 Materials

The task involved watching a video scene, hearing two sentences and then deciding which sentence went best with the scene. For the causative alternation, some of the scenes involved both an Agent and a Theme/Patient, while some involved only a Theme/Patient. One sentence was transitive (e.g., *the lady is opening the door*) and one intransitive (e.g., *the door is opening*). Thus, both sentences are grammatically correct, but one has the same number of arguments as there are participants in the scene and therefore matches the scene better. The verbs used were: *empty, hang, open, fill, melt, cover, spread* and *peel*.

For the investigation of change of location and change of state verbs, four pairs of verbs were chosen where both members of the pair could be used to describe the same scene but one of each pair is restricted to the change of location construction (*pour, put, stack, steal*) and one to the change of state construction (*fill, cover, build, rob*). Each video clip was shown twice at different times in the test, once with the change of location verb in both constructions (e.g., *the girl is pouring orange juice into the cup* vs. *the girl is pouring the cup with orange juice*) and once with the change of state verb (e.g., *the girl is filling a cup with orange juice* vs. *the girl is filling orange juice into the cup*). Again, the participants were asked to choose which sentence sounded best.

The order of all video scenes in this test were randomised and checked by hand to ensure that the same video scene did not appear twice in a row. The order of the target versus non-target sentence was also randomised.

4.2.3.2 Procedure and Scoring

For each item, the participants watched the video scene and the experimenter read out two sentences (with identical intonation). The adult participants wrote down 1 or 2 on a response sheet, for their choice of the first or second sentence. For the children, the experimenter pointed to cards with '1' and '2' written on them while saying the two sentences. Then the child pointed to the card representing their choice of sentence and the experimenter noted down their response.

The responses for the alternating verbs were recorded as either matching or not matching the scene shown. For the change of location / state verbs, responses were recorded as correct versus incorrect according to whether the participants chose the grammatically correct construction or not.

4.3 Results[6]

The initial analysis considers the participants' overall correct scores for the production of argument structure. The results are shown in the boxplot in Figure 4.1. The differences in scores between the groups could not be analysed using an ANOVA due to the unequal variances between the groups, coupled with the unequal numbers in

[6] A preliminary analysis of these results was presented at the Child Language Seminar, Newcastle University, July 2003

each group. Therefore the scores were compared non-parametrically. A Kruskal-Wallis test showed a significant difference between the three groups ($\chi^2(2)$ =29.96, p<0.001). Post-hoc Wilcoxon signed ranks tests showed this was due to significant differences between all three groups: younger versus older children (W=376.5, n_1=22, n_2=23, p=0.003), younger children versus adults (W=235, n_1=10, n_2=22, p<0.001) and older children versus adults (W=276, n_1=10, n_2=23, p<0.001).

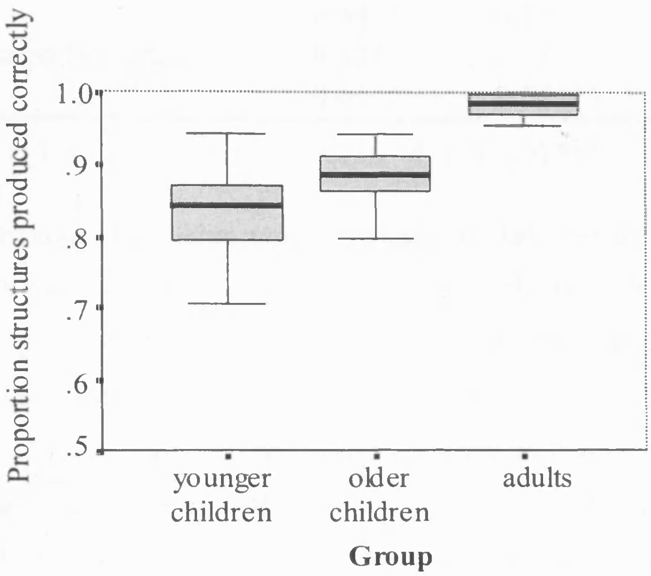


Figure 4.1: Proportion of sentences produced with correct argument structure

In order to investigate the relationship between argument structure performance, age and other language measures, 1-tailed standard and partial Pearson correlations (partialling out the effect of age and performance IQ) were calculated. For the language measures, raw scores were used whereas for the BAS (performance IQ) the z-score was used (raw scores are meaningless as children of different ages are tested on different items). The results are shown in Table 4.2. This shows that once age and IQ have been partialled out, only TROG scores are correlated with overall performance on the argument structure test.

Table 4.2: Standard and partial Pearson correlation coefficients (adjusted for age and IQ) of argument structure score with other measures

	Pearson r	Partial correlations
Age	**0.41****	-
BAS (z-score)	0.02	-
VATT (Tense + Agreement)	**0.43***	0.20
BPVS	**0.44****	0.17
Formulated Sentences	**0.42****	0.18
TROG	**0.66****	**0.56*****

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

4.3.1 Change of location versus change of state verbs

A comparison of change of location verbs (which are transparent to observation) and change of state verbs (which are less transparent to observation) could indicate whether children are using syntactic bootstrapping effectively, as discussed in the Introduction. As a group, the children made very few errors with the change of location verbs *hang, pour, put, roll, spill, steal*: out of 658 attempts at these verbs which included an object, only 3 used the incorrect construction (0.4%) e.g., "the girl is pouring her cup with orange juice". In contrast, for the change of state verbs *build, cover, fill, melt, open,* 28 out of 391 attempts used the incorrect construction (7%), e.g., "the girl filled the juice into the glass" (the total number of attempts for change of state verbs were lower due to exclusion of the verb *rob* for reasons discussed in the Methods section 4.2.2.3).

Figure 4.2 shows the proportion of participants who used or chose the correct construction in the production and judgement tasks (outliers are shown with circles or stars, where stars are more than three box lengths from the lower edge of the box – considered extreme outliers). The adults scored at ceiling on both verb groups and tasks, as did the children for the change of location verbs (hence no boxes are visible). However, the children performed worse on both production (grey) and judgement (hashed) of change of state verbs. These two tasks will be analysed separately as they are not directly comparable due to the 50% chance of choosing the correct sentence in the judgement task.

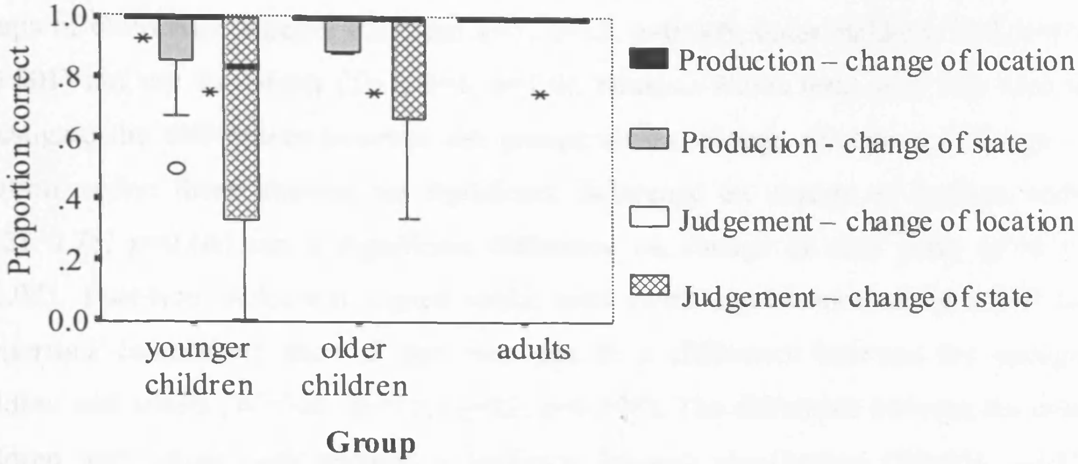


Figure 4.2: Proportion of participants using/choosing correct construction for change of location and change of state verbs in production and judgement tasks

Kruskal-Wallis tests showed a significant effect of group overall for both production ($\chi^2(2)=8.31$, $p=0.014$) and judgement ($\chi^2(2)=14.47$, $p<0.001$). For production, post-hoc Wilcoxon signed ranks tests (with significance set at 0.017 for Bonferroni correction) showed that this was due to a significant difference between the younger children and the adults ($W=303$, $n_1=10$, $n_2=22$, $p=0.006$); the older children showed a tendency towards worse performance than the adults ($W=335$, $n_1=10$, $n_2=23$, $p=0.03$) but the two groups of children did not differ ($W=478$, $n_1=22$, $n_2=23$, $p=0.51$). For judgement, the difference was due to a difference between the adults and both groups of children (younger children: $W=281$, $n_1=10$, $n_2=22$, $p<0.001$; older children: $W=327$, $n_1=10$, $n_2=23$, $p=0.006$) but the difference between the two groups of children failed to reach significance ($W=n_1=22$, $n_2=23$, $p=0.04$). The main effect of verb type was investigated using Wilcoxon matched samples tests which showed a significant difference overall for both production ($T=6$, $n=23$, $p<0.001$) and judgement ($T=7$, $n=14$, $p=0.001$) where performance was worse on change of state than change of location verbs.

Interactions were investigated by carrying out Kruskal-Wallis tests on the subtracted scores (change of location minus change of state) and comparing the performance of the three groups. These showed no significant interaction for production ($\chi^2(2)=4.47$, $p=0.10$), but a significant interaction for judgement ($\chi^2(2)=13.76$, $p<0.001$). The interaction on the judgement task was further investigated by analysing the difference in performance on the two different verb types for each group using Wilcoxon matched samples tests. These showed that the difference between performance on change of state versus change of location verbs was significant for both groups of children, (younger children: T=7, n=13, p=0.005; older children: T=7, n=10, p=0.001) but not for adults (T=1, n=1, p=1.0). Kruskal-Wallis tests were also used to investigate the differences between the groups on the change of state and change of location verbs: these showed no significant difference on change of location verbs ($\chi^2(2)$=0.75, p=0.66) but a significant difference on change of state verbs (χ^2=8.20, p=0.02). Post-hoc Wilcoxon signed ranks tests (with significance set at 0.017 for Bonferroni correction) showed this was due to a difference between the younger children and adults (W=308, n_1=10, n_2=22, p=0.008). The difference between the older children and adults only showed a tendency towards significance (W=351, n_1=10, n_2=23, p=0.04) and the two groups of children (W=448.5, n_1=22, n_2=23, p=0.14) did not differ.

Given that there appears to be a tendency towards a change with age for the change of state verbs (particularly for the judgement task), it is of interest whether this is related to abilities on other language measures. Therefore, correlations and partial correlations were carried out; the results are shown in Table 4.3. This shows that once age and performance IQ have been partialled out, performance on change of state verbs is most strongly related to vocabulary knowledge, both for production and judgement.

Table 4.3: (1-tailed) correlations and partial correlations (partialling out age and IQ) between production and judgement of change of state verbs and other language measures

	Pearson r		**Partial correlations**	
	Production	Judgement	Production	Judgement
Age	0.22	**0.47*****	-	-
BAS (z-score)	-0.07	0.07	-	-
VATT (Tense + Agreement)	-0.21	**0.43***	-0.10	0.19
BPVS	**0.40****	**0.58****	**0.48***	**0.61*****
Formulated Sentences	**0.28***	**0.34***	-0.03	-0.08
TROG	**0.50****	**0.59****	0.09	0.16

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

One of the aims of this chapter was to consider the consistency of individual errors with change of state verbs. This may enable us to distinguish between two possible underlying causes: 1) the children have stored the incorrect thematic core of the verb through limited use of syntactic bootstrapping (consistent errors), or 2) they use the verbs as alternating verbs (inconsistent errors). Only the youngest two children in the study consistently used the change of location construction with individual change of state verbs and therefore seemed to have stored an inaccurate thematic core. One child (aged 5;10) made consistent errors for both *fill* and *cover*, the other (aged 5;4) made consistent errors for *fill* only. However, several other children produced non-alternating change of state verbs in both constructions indicating that they thought the verb could alternate. Ten children used two forms (one correct and one incorrect) for *build* (e.g., "the girl is building a house" and "the girl is building the bricks"), six for *cover* (e.g., "the lady is covering her head with a scarf" and "the lady is covering chocolate spread on the toast") and four for *fill* (e.g., "the lady is filling the jar with yummy sweets" and "the girl was filling orange juice into her glass"). This error pattern was produced by children across the age range including both the youngest and oldest child (aged 14;11) in the study and suggests that they may view these verbs as alternating verbs.

4.3.2 Use of verb alternations: dative and locative alternations

This section investigates the participants' willingness to use *alternating* verbs in both constructions associated with the dative and locative alternations and to establish any preferences they may have for a particular construction, either in general or for particular verbs, and whether these preferences change with age. For both alternations the participants could choose either construction to describe the video scenes. For the locative alternation, the choice is between using the change of location and change of state constructions (e.g., *the man is wiping the crumbs off the table* vs. *the man is wiping the table*) and for the dative alternation, between the prepositional and ditransitive constructions (e.g., *the man is giving the present to the girl* vs. *the man is giving the girl the present*). Table 4.4 shows the mean use of the change of state construction for the locative alternation and the ditransitive construction for the dative alternation. Equal use of the two possible constructions for each alternation would result in a score of 0.5.

Table 4.4: Mean (SD) use of change of state construction for locative alternation and ditransitive construction for dative alternation

Construction	Younger children	Older children	Adults
Change of state construction (loc alt)	0.55 *(0.15)*	0.64 *(0.17)*	0.71 *(0.15)*
Ditransitive construction (dat alt)	0.44 *(0.25)*	0.57 *(0.27)*	0.56 *(0.26)*

A repeated measures 2x3 ANOVA (alternation x Group) showed a significant main effect of Group ($F(2)=3.83$, $p=0.03$, $\eta^2=0.13$) and alternation ($F(1)=6.90$, $p=0.01$, $\eta^2=0.12$), but no interaction ($F(2)=0.33$, $p=0.72$, $\eta^2=0.01$). The main effect of Group was due to a trend for the younger children to use the tabled constructions less than the older children and adults, but no Bonferroni-corrected pairwise comparisons reached significance (younger vs. older children $p=0.08$ and vs. adults $p=0.07$; older children vs. adults $p=1.0$). The main effect of alternation was investigated further by considering whether the participants showed a preference for one construction or used the construction listed in the table 50% of the time. One-sample t-tests showed that as a group, the participants used the change of state construction for the locative alternation significantly more than 50% of the time ($t(54)=5.24$, $p<0.001$, $d=1.41$) while use of the ditransitive construction with verbs which can undergo the dative alternation did not differ significantly from 50% ($t(54)=0.52$, $p=0.61$, $d=0.14$).

Thus the participants as a group showed a preference for the change of state construction with verbs which can undergo the locative alternation, but showed no preference for either the ditransitive or prepositional construction with verbs which can undergo the dative alternation. However, it is of interest whether this pattern held across all verbs or whether there was any variation between verbs. Table 4.5 shows considerable variation between verbs for both adults and children for both the locative and dative alternations. The children show very similar patterns to the adults, tending to use the change of location construction for *spread* and the change of state construction for *peel* and *wipe* and both constructions fairly equally with *empty*. They do however differ on *pack*; the adults use the change of state construction more, whereas the children use both constructions fairly equally. For the dative alternation, both adults and children use the verb *give* in the ditransitive construction more than the verb *pass*, however the verb *pass* seems to show some development over time, with the younger children least likely and the adults most likely to use the ditransitive construction.

Table 4.5: Variation between verbs in use of locative and dative alternations. Proportion of verbs in change of state construction (for locative alternation) or ditransitive construction (for dative alternation)

Alternation	Verb	Younger children	Older children	Adults
Locative alternation (change of state)	spread	0.07	0.04	0.25
	pack	0.47	0.57	0.83
	empty	0.45	0.60	0.60
	peel	0.86	1.00	1.00
	wipe	0.96	1.00	0.95
Dative alternation (ditransitive)	give	0.74	0.83	0.80
	pass	0.24	0.46	0.67

4.3.3 Use of verb alternations: causative alternation

The causative alternation is analysed separately from the locative and dative alternations as pragmatic considerations mean that the use of one form of the alternation is always preferable to the other, depending on the number of participants in the video scene.

4.3.3.1 Production

This section considers whether the children attempted to use the construction (transitive or intransitive) that matched the transitivity of the scene. Figure 4.3 shows that the adults predominantly used the construction which best matches the scene for both intransitive and transitive scenes. The only mismatches were with the verb *melt* where 3/10 adults used "the chocolate is melting" for the transitive scene of a man melting chocolate. This could be because they did not see the causation as direct, given that heat directly causes chocolate to melt, not people.

The children performed in a similar way to the adults for the transitive scenes, but often did not use the intransitive construction for an intransitive scene. Instead they frequently 'invented' an Agent which was not present in the video scene. They used different strategies to do this e.g., "<u>she</u> is spreading some milk", "<u>she</u> poured the water", "<u>someone</u> is peeling a wall", "<u>someone</u> covered the table with a cloth", "<u>a ghost</u> opened the door" (all examples from one child aged 6;5 years). Some of the older children used the passive construction where an Agent is understood but not expressed e.g., "the paint is getting peeled off the wall".

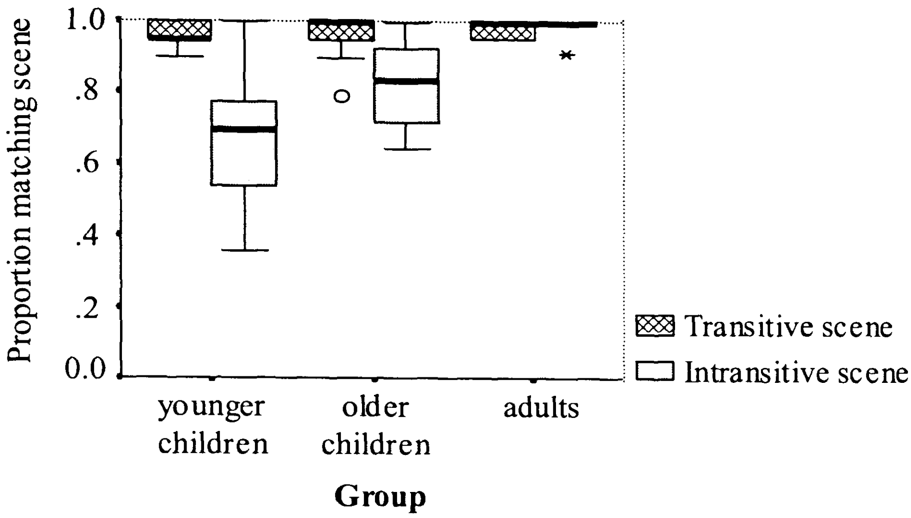


Figure 4.3: Use of construction which best matches video scene

Statistical analyses of the data shown in Figure 4.3 were non-parametric due to the strong ceiling effects for the adults in general and for the children for the transitive scenes. Overall scores averaged for both conditions were analysed in a Kruskal Wallis test and showed a main effect of group ($\chi^2(2)=25.3$, $p<0.001$). Post-hoc Wilcoxon signed ranks tests showed this was due to significant differences between all three groups: younger versus older children ($W=388.5$, $n_1=22$, $n_2=23$, $p=0.007$), younger children versus adults ($W=261.5$, $n_1=10$, $n_2=22$, $p<0.001$) and the older children versus adults ($W=285.5$, $n_1=10$, $n_2=23$, $p<0.001$). The main effect of scene type was analysed using Wilcoxon matched pairs tests and showed a significant effect where the matching construction was less likely to be used for intransitive scenes ($T=92$, $n=48$, $p<0.001$). The interactions between scene type and group were analysed by subtracting the scores on intransitive scenes from those on transitive scenes and performing a Kruskal-Wallis test to compare the groups on this subtracted score. This showed a significant interaction between group and scene type ($\chi^2(2)=19.65$, $p<0.001$). This interaction was investigated further by considering the patterns of performance for each group separately. Wilcoxon matched samples tests showed a significant difference between transitive and intransitive scenes for the younger ($T=3$, $n=21$, $p<0.001$) and older children ($T=25$, $n=22$, $p<0.001$) but not for the adults ($T=5$, $n=5$, $p=0.75$). The performance of the three groups was also compared for each scene type. For the transitive scenes no difference between the groups was found ($\chi^2(2)=2.82$, $p=0.25$), but the groups differed significantly on the intransitive scenes ($\chi^2(2)=19.65$, $p<0.001$). Post-hoc Wilcoxon signed ranks tests showed that the younger children used the matching construction significantly less than the older children ($W=382$, $n_1=22$, $n_2=23$, $p=0.004$) and adults ($W=266$, $n_1=10$, $n_2=22$, $p<0.001$) and the older children also performed less well than the adults ($W=310$, $n_1=10$, $n_2=23$, $p<0.001$).

In summary, the significant differences in performance between the three groups were due to differing performance on the intransitive scenes only. All groups were able to use the matching construction for the transitive scenes equally well.

Given that the ability to use the intransitive construction for intransitive scenes seems to develop with age, it is important to establish whether this has any relation to other language tests. As for the overall argument structure test scores, correlations with other language tests were analysed with and without age and performance IQ partialled out. The results are shown in Table 4.6. This shows that after the effects of age and performance IQ have been partialled out, scores on the TROG are most closely related to the ability to use the intransitive construction with alternating verbs.

Table 4.6: Correlations of use of intransitive construction for intransitive scene with language measures

	Pearson r	**Partial correlations**
Age	**0.46****	-
BAS (z-score)	**-0.31***	-
VATT (Tense + Agreement)	0.24	0.07
BPVS	**0.50****	0.11
Formulated Sentences	**0.44****	0.20
TROG	**0.51****	**0.42***

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

Qualitative analysis of individual results showed that even some of the oldest children in the study persisted in using the transitive construction where the intransitive construction would be more pragmatically accurate. Therefore, although the usage pattern appears to develop with age, even the oldest children did not perform like adults. Only one adult used the transitive construction for an intransitive scene on one occasion, but some 14 year olds still did this fairly frequently. This raises the question as to whether this pattern of performance is merely seen in production tasks, or whether it permeates their linguistic system. The judgement task may throw further light on this.

4.3.3.2 Judgement

The boxplot in Figure 4.4 shows the judgement data and looks remarkably similar to the plot of the production data in Figure 4.3. Again, the children seemed to have particular difficulty when an intransitive scene was shown. In such cases, they chose the transitive construction, even though the scene was intransitive and the verb can alternate. The adults did not make such choices and the children's performance seemed to progress towards the adult pattern with age.

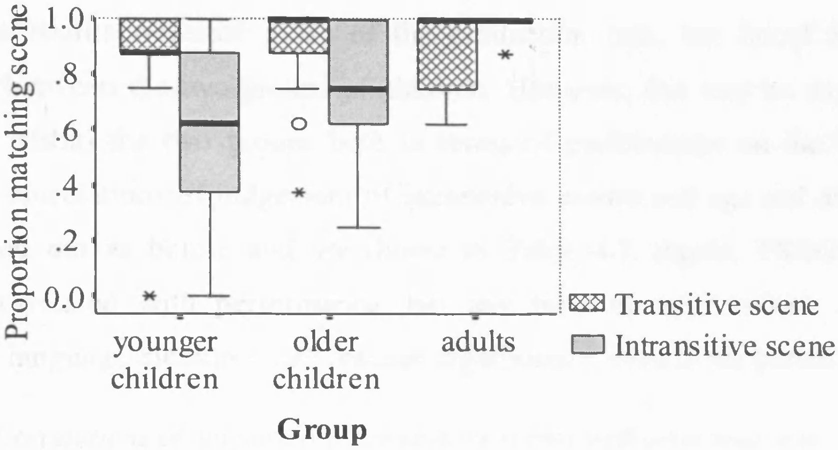


Figure 4.4: Choice of construction which best matches video scene in the judgement task

Again, due to the strong ceiling effects, non-parametric analyses were used. Overall scores averaged for both conditions were analysed in a Kruskal Wallis test and showed a main effect of group ($\chi^2(2)=10.9$, $p=0.003$). Wilcoxon signed ranks test showed this was due to a significant difference between the younger children and the adults ($W=2.84.5$, $n_1=10$, $n_2=22$, $p=0.001$) and the older children and adults ($W=56.5$, $n_1=10$, $n_2=23$, $p=0.017$), but the younger and older children did not differ ($W=446.5$, $n_1=22$, $n_2=23$, $p=0.18$). The main effect of scene type was analysed using Wilcoxon matched pairs tests and showed a significant effect where the matching construction was less likely to be chosen for intransitive scenes ($T=96$, $n=33$, $p<0.001$). The interactions between scene type and group were analysed by subtracting the scores on intransitive scenes from those on transitive scenes and performing a Kruskal-Wallis test to compare the groups on this subtracted score. This showed a significant interaction between group and scene type ($\chi^2(2)=8.50$, $p=0.01$). This interaction was investigated further by considering the patterns of performance for each group separately. Wilcoxon matched samples tests showed a significant difference between transitive and intransitive scenes for the younger ($T=7.5$, $n=15$, $p=0.003$) and older children ($T=18$, $n=14$, $p=0.04$) but not for the adults ($T=0$, $n=4$, $p=0.13$). The performance of the three groups was also compared for each scene type. The groups did not differ on the transitive scenes ($\chi^2(2)=1.90$, $p=0.39$), but differed significantly on the intransitive scenes ($\chi^2(2)=14.53$, $p<0.001$). Post-hoc Wilcoxon signed ranks tests showed the younger children were less able to make accurate judgements for the intransitive scenes than the adults ($W=276$, $n_1=10$, $n_2=22$, $p<0.001$) as were the older children ($W=321$, $n_1=10$, $n_2=23$, $p=0.005$), but no significant difference was found between the two groups of children ($W=438$, $n_1=22$, $n_2=23$, $p=0.12$).

The results reflected those of the production task, but found no significant difference between the two groups of children. However, this may be due to the wide variability within the two groups both in terms of performance on the task and age. Therefore, correlations of judgement of intransitive scenes and age and other measures were carried out as before and are shown in Table 4.7. Again, TROG scores were strongly correlated with performance, but this time the correlations with the two expressive language measures also reached significance, even in the partial correlations.

Table 4.7: Correlations of judgement of intransitive scenes with other measures

	Pearson r	**correlations**
Age	**0.31***	-
BAS (z-score)	-0.14	-
VATT (Tense + Agreement)	**0.37***	**0.38***
BPVS	**0.34***	0.15
Formulated Sentences	**0.40****	**0.40***
TROG	**0.39****	**0.41***

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

4.3.3.3 Detransitivisation versus causativisation

The argument structure test used in this study included two of Levin and Rappaport Hovav's (1995) groups of verbs (see section 2.1.3): 1) externally caused verbs which detransitivise (e.g., *open, melt, roll, hang*) and 2) verbs with two semantic representations (one internally and one externally caused: *roll, hang*). The results in the previous two sections indicate that children have difficulty detransitivising externally caused verbs as shown by their persisting use (and choice) of the transitive construction for intransitive scenes (see Figures 4.3 and 4.4). Detailed inspection of the verbs *roll* and *hang* could help confirm this hypothesis because they belong to both groups. In the production test, these verbs are shown in three different scenes which link to three different constructions, according to Levin and Rappaport Hovav's (1995) theory:

1. external Agent causes Theme to move (externally caused – transitive construction: *the man is rolling the ball along the floor*)
2. animate volitional Theme moves (internally caused – unergative intransitive construction: *the lady is rolling off the bed*)
3. inanimate Theme moves (externally caused, but Agent does not need to be lexically expressed – unaccusative intransitive construction derived from the transitive construction via detransitivisation: *the pencil is rolling down the slope*).

Therefore it is of interest to see whether there is any difference between the children's use of intransitive constructions in scenes where the Theme is animate versus inanimate (i.e., internally vs. externally caused and unergative vs. unaccusative). The proportion of children using the intransitive construction with intransitive scenes is shown in Table 4.8 split according to whether the Agent is animate or inanimate.

Table 4.8: Proportion of children using intransitive construction

Verb	**Animate Theme = unergative**	**Inanimate Theme = unaccusative**
hang	1.00	0.80
roll	1.00	0.80

This shows that the children all use the intransitive construction for an intransitive scene with an animate Theme (e.g., *the lady is rolling off the bed*: unergative), but only 80% of them do so when the Theme is inanimate (e.g., *the pencil is rolling down the slope*: unaccusative), using the transitive construction instead (e.g., "someone is rolling the pencil down the slope"). Thus, the children have no difficulty producing an intransitive construction with the verbs *hang* and *roll*, but 20% of them did not do so when the motion of the Theme was externally caused but no Agent was visible. This included children aged between 5;4 and 13;8.

4.3.4 Obligatory arguments

The adult data set revealed only two instances of an omitted obligatory argument. The children, however, made many errors, but this was not constant across the argument types. In total, the 45 children attempted 3007 sentences and only omitted 13 subjects (0.4%), they made 787 attempts at sentences with obligatory object arguments and made 17 omissions (2%) and 593 attempts at sentences with obligatory prepositional phrases or particles and made 113 omissions (19%). A Friedman analysis of the proportion of arguments omitted showed this difference between argument types was significant ($\chi^2(2)=69.35$, $p<0.001$). Post-hoc Wilcoxon matched samples tests (with significance set at 0.017 for Bonferroni correction) showed this was due to a significant difference between the proportion of obligatory prepositional phrases omitted compared to the number of subjects ($T=3$, $n=43$, $p<0.001$) and objects ($T=0$, $n=42$, $p<0.001$), with a trend towards a difference between the number of omitted subjects and objects ($T=26.5$, $n=16$, $p=0.03$). Comparisons of the two age groups using Wilcoxon signed ranks tests showed that they did not differ in their omission of obligatory arguments overall ($W=491.5$, $n_1=22$, $n_2=23$, $p=0.41$), or on omission of the object ($W=461.5$, $n_1=22$, $n_2=23$, $p=0.06$) or prepositional phrases ($W=520$, $n_1=22$, $n_2=23$, $p=0.84$), however, the younger children omitted significantly more subjects than the older children ($W=184$, $n_1=22$, $n_2=23$, $p=0.009$).

However, the omission of obligatory arguments was also dependent on the number of arguments required by the verb. The boxplot in Figure 4.5 shows the proportion of sentences with a missing argument by group, split according to the number of arguments required by the verb. This shows that the adults made virtually no omissions and only the younger children omitted some subjects and objects. Prepositional phrases were the most common omission for both groups of children, particularly with verbs requiring only two arguments (grey).

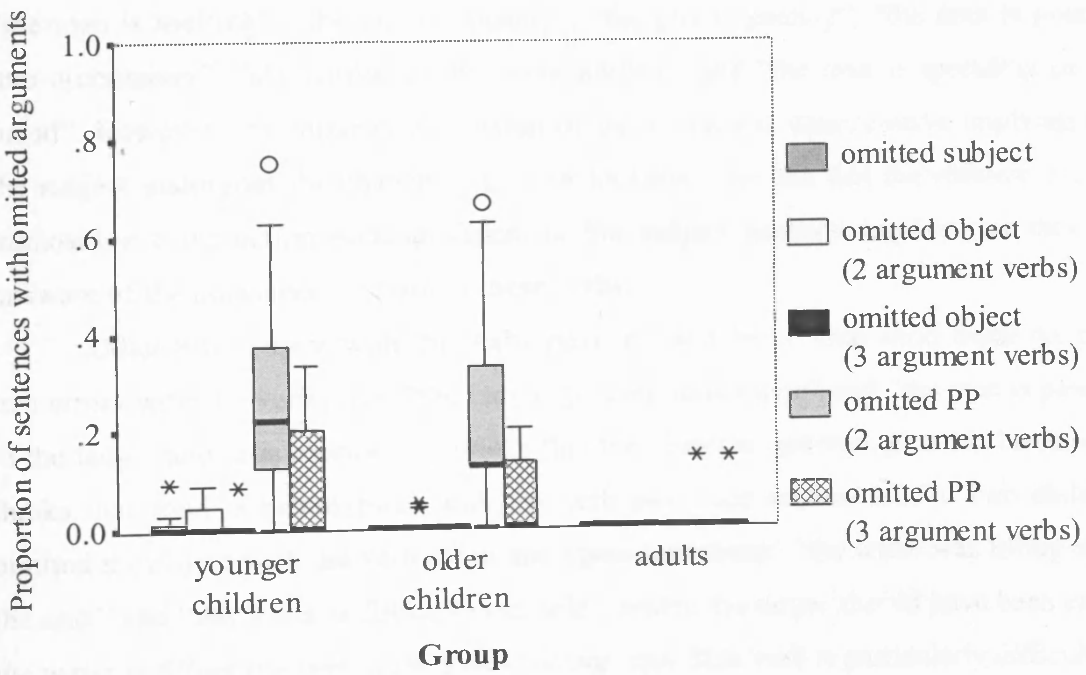


Figure 4.5: Proportion of sentences with omitted arguments

The differences between argument omissions with verbs requiring two or three arguments was analysed for each group of children for objects and prepositional phrases separately. The younger children showed a significant difference both for omitted objects ($p=0.007$) and omitted prepositional phrases ($p=0.001$), whereas for the older children, the difference only reached significance for prepositional phrases ($p<0.001$) and not for objects ($p=0.11$).

In Chapter 2, I discussed the possibility that children might learn whether arguments are obligatory or not either statistically or via parental corrective feedback. In both cases, we would expect fewer errors on verbs which are used more frequently. Thus, we would expect negative correlations between omitted arguments and verb frequency. Spearman rank correlations (1-tailed) were therefore carried out by verb comparing omission of obligatory arguments with a frequency measure (Brown, 1984). These showed a significant negative correlation of verb frequency with omission of obligatory prepositional phrases ($r=-0.73$, $p=0.001$) but not with obligatory objects ($r=-0.23$, $p=0.07$). Therefore, for omitted objects, some other factor may be involved.

Of the 17 sentences where an obligatory object was omitted, 7 were with verbs which can undergo the causative alternation: *melt, open, peel, pour, spill* and *spread*. In this case the children produced an intransitive construction but with an Agent in subject position rather than the Theme, as if they were transitive with an optional object, e.g., "the man is melting", "the girl is opening", "the girl is peeling", "the man is pouring into a container", "she spilled on the work surface" and "the man is spreading on the bread". However, the intransitive version of these verbs is unaccusative implying that the subject undergoes the change of state or location. The fact that the children use the intransitive construction with an Agent in the subject position implies that they are unaware of the unaccusative form of these verbs.

Other errors were with the verbs *pass, fill* and *build*. One child made the only two errors with the verb *pass* ("the lady is passing to the man" and "the man is passing to the lady") and thus presumably thinks that the object is optional, possibly because he thinks that food is prototypical with the verb *pass* (see section 2.2.3). Two children omitted the object with the verb *fill* in the Agent-less scene: "the water was filling up in the sink" and "the water is filling to the hole", where the target should have been either *the water is filling the sink* or *the sink is filling (up)*. This verb is particularly difficult, as the intransitive construction requires the Goal (not the Theme) to be in the subject position unlike most other alternating verbs. If the Theme is in the subject position with this verb, the transitive construction needs to be used.

The other main type of error (6 of the 17 errors) was with the verb *build*. Recall that due to the nature of the adult data for this verb, for the scene involving a *house*, the object was marked as optional and for the other scenes as obligatory. Hence if the children omitted either *car* or *tower*, their responses were scored as missing an obligatory object argument. One child omitted *car* and five children omitted *tower*. It is possible that for young children, a *tower* is a prototypical object for building and they therefore tend to treat this as optional.

4.4 Discussion

The results of this study showed a developmental trend towards more accurate use of argument structure in general (which was most closely associated with developing scores on the TROG) and in particular with the accurate production and judgement of change of state verbs and the use and judgement of the unaccusative construction with verbs which can undergo the causative alternation.

The individual results for change of state verbs, discussed in section 4.3.1 showed that only the youngest two children consistently used the incorrect construction, like Bowerman's daughter Eva (Bowerman, 1982), while the older children made inconsistent errors. Although these errors reduced with age, they continued into the teenage years; however, the adults always used these verbs appropriately.

These data suggest a possible developmental pattern whereby children around the age of 5 years view these change of state verbs as non-alternating change of location verbs, then later as alternating verbs and later still as non-alternating change of state verbs. This would be explained by the hypothesis discussed in Chapter 2 where younger children learn verb meanings from observation alone leading to incorrect thematic cores for verbs which are less transparent to observation (like change of state verbs). If they then apply linking rules to these incorrect thematic cores, the incorrect construction will result. A change in their pattern of use of change of state verbs could be due to increased observation, where they observe the verb being use in a context which does not match their stored semantic representation or to the use of syntactic bootstrapping. Both of these possibilities could lead to a change in the stored thematic core and hence use of the verb in the change of state construction. However, at this stage, they may view these verbs as alternating verbs. As discussed in section 2.2.4, in order to identify which verbs do not alternate, children could use statistical evidence or parental corrective feedback. They could then use the information gained from this to hypothesise broad and narrow range rules (see section 2.2.2.1). Continued use of a verb as an alternating verb could be due to a lack of knowledge of narrow range rules or assignment of the verb to the incorrect narrow conflation class. The significant correlation of performance on change of state verbs with the BPVS (and not the TROG) indicates that the use of such verbs as alternating verbs may be more related to semantic than syntactic knowledge. Knowledge of the meaning of a verb is not categorical; a child may have underspecified semantic representations of verbs which lead to assignment of the verbs to the incorrect narrow conflation class. This in turn could lead to use of these verbs as alternating verbs. Increased specification of the verbs' semantic representations could lead to their assignment to the correct narrow conflation class and thus the narrow range rules of English would correctly restrict the verbs to the change of state construction only.

4.4.1 Alternations

This chapter aimed to establish whether children use both forms of alternations with alternating verbs and whether they show any change with age. It clearly is the case that many children do use both forms of alternations, however, their pattern of use varies from one alternation to the other. For the dative alternation, as a group, they used both constructions (ditransitive vs prepositional) equally, unlike the younger children in the study by Osgood & Zehler (1981) who used the prepositional construction more frequently than the ditransitive construction. However, analyses by verb showed that (in line with the adults) the children in this study used the ditransitive construction more with *give* and the prepositional construction more with *pass*. How can the theories of argument structure outlined in Chapter 2 account for this? In Jackendoff's (1990) theory, the dative alternation occurs because each verb has two semantic representations; in one the Goal is also the Beneficiary (leading to the ditransitive construction) and in the other it is not (leading to the prepositional construction). Given this theory, it is unclear why the form with the Beneficiary should be used more for *give* and less for *pass*. This cannot be a result of the video scenes as one of the scenes with *give* involved passing an item of rubbish which the recipient put in the bin; it is therefore difficult to see how the Goal (or recipient) could have been construed as a Beneficiary in this case. In contrast, all scenes involving *pass* involved passing items of food, which the recipient ate, thus they have more clearly benefited from the transfer than in the case of *give* above. The theories of Pinker (1989) and Goldberg (1995) account better for the differences between *give* and *pass*. The difference between these verbs could be due to a subtle difference in root meaning: *give* necessarily implies that the Goal comes to possess the Theme, whereas the Goal in *pass* only denotes the resultant location of the Theme. In Pinker's (1989) theory, the semantic broad range rule concerning use of the ditransitive construction of the alternation states that the Goal must possess the Theme, thus the verb *give* would be more likely to undergo the alternation. In terms of Goldberg's (1995) construction grammar theory, the fact that the meaning of *give* necessarily involves transfer of possession means that it canonically occurs with the ditransitive construction. Use of *pass* with the ditransitive construction would be non-canonical because the meaning of transfer of possession is contributed only by the construction, the verb only contributes the *means* of that transfer.

For the locative alternation, when individual verbs are considered, the adults and children showed particular construction preferences for individual verbs, preferring the change of state construction for *wipe* and *peel* and the change of location construction for *spread*. The adults also preferred the change of state construction for *pack*, whereas the children showed no preference with this verb. Both adults and children used both constructions equally for *empty*. None of the theories of argument structure discussed in Chapter 2 adequately account for this finding. Pinker (1989) proposes that the locative alternation consists of a rule relating two separately stored thematic cores for each verb. He proposes that the change of state construction is used when the Goal/Source is completely affected. Of the verbs in this test, *empty* always implies that the Source is completely affected as part of the root meaning of the verb. Therefore it is surprising that this is the verb where both adults and children used both constructions equally. In contrast, *peel, spread,* and *pack* do not necessarily imply that the Goal is completely affected (an apple could be half-peeled, a piece of bread half-spread or a bag only half-packed). Indeed the test was carefully constructed to include such examples as well as examples where the Goal was completely peeled, covered or filled. Therefore Pinker's (1989) theory would predict that the participants should use the change of state construction more for *empty* than for *peel, spread* and *pack*. While this was the case for *spread*, the reverse was found for *peel* and *pack* (for the adults). Thus, the analyses from the individual verbs do not provide support for Pinker's (1989) theory. However, it is also not clear how the theories of Goldberg (1995) or Jackendoff (1990) could cope with this wide variation between verbs either. In Jackendoff's (1990) theory, the Theme would need to be 'more optional' for some verbs than others and it is unclear how such a concept could be accommodated.

For the causative alternation, the adults predominantly used the construction which best matched the scene shown. The children also used the matching construction when shown a transitive scene but when shown an intransitive scene, they frequently used (and chose in a judgement task) the transitive construction, thus inventing an Agent which was not present in the scene. This type of error was also reported by Schelletter et al. (1998). However, although the children's performance in this study did become more like that of the adults with increasing age, even some of the oldest children still failed to use the intransitive construction for some alternating verbs.

A particular consideration for the causative alternation was whether the data in this study provide any evidence for Levin and Rappaport Hovav's (1995) theory that the 'causative alternation' is not a single process. They propose that the 'alternation' results either from two different underlying semantic representations of the verb or from one of two processes: causativisation or detransitivisation. This study did not investigate the minority of verbs which they claim are subject to causativisation, but only investigated verbs which undergo detransitivisation and those which have two semantic representations. The children showed evidence of using verbs which have two semantic representations. For *roll* and *hang*, they had no difficulties using the transitive construction to describe transitive scenes involving an Agent and a Theme or using the intransitive construction to describe intransitive scenes where the action of the Agent/Theme is internally caused. However, the results indicate that they did have difficulty with detransitivisation. 20% of children did not use the intransitive (unaccusative) construction with *roll* and *hang* when the Theme was inanimate and hence its motion or spatial configuration was likely to have been externally caused by an Agent not visible in the scene. They also had difficulties using the other alternating verbs in the intransitive construction where no Agent was present. It is therefore possible that for these children, these verbs are transitive verbs (as per Levin and Rappaport's hypothesis) and they either have difficulty *using* the process of detransitivisation or they are unaware that these verbs can undergo detransitivisation, i.e., that the Agent is optionally expressed (see Jackendoff, 1990; 2002). This second option is more likely given that they chose the transitive forms for intransitive scenes in the judgement task. If they merely had difficulty *producing* unaccusative forms, they would be expected to choose the matching construction on a judgement task. This study therefore provides evidence in favour of Jackendoff (1990) and Levin and Rappaport Hovav's (1995) theories that the predominant process in the causative alternation is one of detransitivisation and not of causativisation, as hypothesised by Pinker (1989) and Goldberg (1995).

Studies investigating the use of causativisation and detransitivisation with children from 2-7 years with novel verbs (Brooks & Tomasello, 1999; Brooks & Zizak, 2002) found the children were more likely to use causativisation than detransitivisation, indicating that causativisation is the more productive process in this age range. In the study described in this chapter using older children aged 5-15 years with real alternating verbs, the use of detransitivisation increased with age, indicating that the children are still acquiring this process. It is possible that during this older age range they begin to recognise that the predominant process is one of detransitivisation as opposed to causativisation. This rule may not yet be productive for all of the children. However, the ages at which the children failed to detransitivise was unexpected given that the studies discussed in Chapter 2 tend to conclude that children have mastered the causative alternation by 8 years of age. In this study, failure to detransitivise occurred far beyond this age. Although use of this process did increase with age, some of the teenagers still failed to use the unaccusative versions of some of these verbs. Thus it seems that children's ability to use the causative alternation (and detransitivisation in particular) still has not reached adult-like performance by the age of 15 years. This unanticipated finding deserves further investigation. The children and teenagers all fell within the normal range for language and non-verbal tests (average z-scores of approximately 0.3), but it is possible that the adult participants were not representative of adults in general given that they had all received a university education and hence are likely to be above the normal range on linguistic and general performance measures. A group of adults more representative of the general population may perform in a similar way to the teenagers in this study. If this is the case, then the implications for linguistic research are wide-ranging. It is often assumed that variation in adult performance on tasks such as the one presented here is minimal and therefore the standard against which the children's performance is judged is often either the author's own intuitions or the performance of undergraduates who again are likely to be unrepresentative of the general population. Thus, the extent of variability within the adult population needs to be investigated.

4.4.2 Omission of obligatory arguments

The investigation of argument omissions showed the children omitted more obligatory arguments than the adults. Prepositional phrases were omitted most frequently, particularly in verbs requiring only two arguments (i.e., a Subject and a Prepositional Phrase). These all involve use of the intransitive construction with verbs which can undergo the causative alternation. We have already discussed above that several children seem to have difficulty using detransitivisation and invent an Agent argument. However, the evidence from omission of arguments shows that when they *do* use detransitivisation they frequently omit obligatory prepositional phrases. This therefore provides further evidence of the significant difficulty the children have using detransitivisation.

In section 2.2.3, I discussed the methods by which children could mark the obligatoriness of arguments. They could do this statistically, or use parental corrective feedback. In both cases, they should make fewer errors with verbs which they or their parents use with high frequency. Therefore I looked for any relationship between omissions of arguments and verb frequency. Omission of obligatory prepositional phrases was negatively correlated with frequency. Thus, children are more likely to mark obligatory prepositional phrase arguments as such with high frequency than low frequency verbs. This could be because they have heard adults use high frequency verbs and their obligatory prepositional phrase arguments more often than low frequency verbs and are thus more likely to assume these arguments are obligatory purely on a statistical basis. Also, they themselves use high frequency verbs more often and may therefore have received more parental feedback (Saxton, 2000) regarding the obligatoriness of these arguments.

For omission of obligatory objects however, other factors seemed to be more important. For example, the children omitted more objects with verbs which can undergo detransitivisation. This could be because they have heard the verbs in the intransitive construction and have therefore marked the object as optional. However, they do not seem to have registered that the intransitive construction is unaccusative and has been achieved through detransitivisation. This provides further evidence for the claim (above) that some of the children have difficulty with or are unaware of the process of detransitivisation.

Another factor involved in omission of obligatory objects seems to be whether the object is prototypical for the verb. Rappaport Hovav and Levin (1998) have proposed that for some verbs, prototypical objects can be omitted. However, children and adults may have different ideas regarding which objects are prototypical. For children, a tower of toy blocks appears to be a prototypical object for the verb *building* (but a car is not), whereas for adults, only a building of some kind (such as a house) is prototypical.

4.5 Conclusions

When considering children's use of verb alternations, we need to distinguish knowledge of the underlying rule of the alternation and application (and restriction) of this rule to individual verbs. The results of this study lead to the conclusion that as a group, the children are aware of the locative and dative alternation and show a similar pattern of use to adults. Their pattern of use of these alternations with individual verbs is also very similar to that of the adults, suggesting some statistical learning from the input where they use verbs in similar ways to those used by adults. However, the children do tend to overgeneralise the locative alternation for change of state verbs, suggesting rule-based learning. The data indicate a developmental pattern whereby the younger children (aged 5 years) use some change of state verbs purely in the change of location construction (possibly due to limited use of syntactic bootstrapping), some older children use these verbs as alternating verbs (possibly because of underspecified semantic representations and hence assignment of the verb to the wrong narrow conflation class) while for others their use is (correctly) restricted only to the change of state construction. Given that this study is cross-sectional, strong conclusions cannot be drawn from these data, but the results indicate a developmental progression which merits further investigation, possibly in a longtitudinal study.

The causative alternation differs from the locative and dative alternations in that the children show a different pattern of performance to the adults. Specifically, I hypothesised that they have difficulty using detransitivisation for alternating verbs. The evidence for this hypothesis comes from several sources: the children often use transitive sentences for intransitive scenes, they often omit obligatory (Patient/Theme) objects when the Agent is in the subject position (seeming not to realise that this changes the thematic role of the Subject to Patient/Theme) and when they do use detransitivisation, they frequently omit obligatory prepositional phrases. The majority of omissions of obligatory arguments can be accounted for by the hypothesised difficulty with detransitivisation, but there is also some correlational evidence for the use of statistical evidence and/or parental feedback in the use of obligatory prepositional phrases.

In summary, the children in this study differ from adults in their use of argument structure in several ways, but particularly in their use of the causative alternation and production of change of state verbs. Thus, this study shows that the use and understanding of argument structure continues to develop in school-aged children. Therefore, when considering the abilities of children with language impairments, it is important to compare their performance with typically developing children of the same age and/or language levels. This is the focus of Chapter 5.

CHAPTER 5 ARGUMENT STRUCTURE IN SPECIFIC LANGUAGE IMPAIRMENT

5.1 Introduction and aims of chapter

The literature regarding the abilities of children with SLI to use argument structure accurately is limited and the results are often contradictory (see Chapter 2, section 2.3). Therefore this chapter aims to further investigate whether children with SLI have difficulties with argument structure compared to controls matched on age, vocabulary (BPVS) or sentence comprehension (TROG). In particular, I will investigate production of change of state verbs, the use of verb alternations and omission of obligatory arguments to establish whether the performance of children with SLI is comparable to the typical developmental patterns revealed in Chapter 4.

5.2 Method

The participants involved in this study are described in Chapter 3 together with the criteria for matching the controls to the children with SLI. The argument structure tests used in this chapter are the same as those in Chapter 4 and are described there.

5.3 Results[7]

Throughout this section, all investigations first compare the four groups of children (SLI, TROG, BPVS and age controls) in an overall analysis (e.g., an ANOVA or Kruskal Wallis test) and then three planned comparisons compare the SLI group with each of their control groups. A Bonferroni correction is applied (adjusting the level of significance to 0.017) to reduce Type I errors. The control groups are not compared with each other for two reasons: 1) the control children's performance has already been investigated in detail in Chapter 4 and 2) the control groups are only relevant in terms of their relationship to the SLI children. Thus, only three planned comparisons are carried out rather than six post-hoc comparisons of all combinations of the four groups, thus reducing the severity of the Bonferroni correction and hence increasing the power.

The initial analysis considers the participants' overall scores for the production of argument structure. The results are shown in the boxplot in Figure 5.1.

[7] A preliminary analysis of these results was presented at the Child Language Seminar, University of Newcastle, 2003

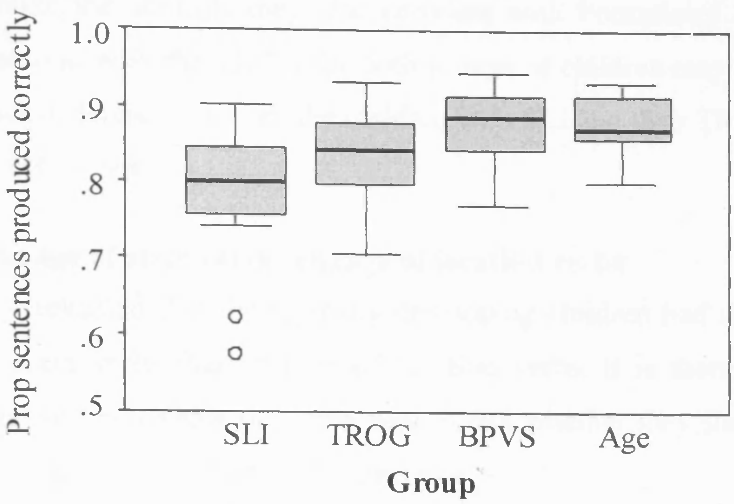


Figure 5.1: Proportion of sentences produced with correct argument structure

A one-way ANOVA revealed a significant difference between groups on this general measure ($F(3,56)=6.92$, $p<0.001$, $\eta^2=0.27$). Planned comparisons of the children with SLI with each of their control groups showed significant differences between their performance and that of their age ($p<0.001$, $d=1.02$) and BPVS controls ($p<0.001$, $d=0.98$) but no significant difference when compared to their TROG controls ($p=0.056$, $d=0.51$).

In order to investigate the relationship between argument structure performance and other language measures in SLI, separate (1-tailed) correlations were performed. Standard and partial correlations (partialling out the effect of age and performance IQ) were calculated comparing the argument structure scores with raw scores on the language measures. Table 5.1 shows the correlations for the 15 children with SLI and the 45 controls (from Chapter 4, for comparison).

Table 5.1: Pearson r and partial correlation coefficients (adjusted for age and performance IQ) of argument structure score with other measures.

	Pearson r		**Partial correlations**	
	SLI	Controls	SLI	Controls
Age	0.34	**0.41****	-	-
BAS (z-score)	0.39	0.02	-	-
VATT (Tense + Agreement)	0.27	**0.43***	0.32	0.20
BPVS	**0.57***	**0.44****	0.41	0.17
Formulated Sentences	**0.85****	**0.42****	**0.87*****	0.18
TROG	**0.77****	**0.66****	**0.69****	**0.56*****

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

Table 5.1 shows that once age and IQ have been partialled out, argument structure scores in the children with SLI correlate with the TROG as for the control children, but unlike the controls they also correlate with Formulated Sentences. The significant correlation with the TROG for both groups of children may account for the lack of significant difference between the children with SLI and their TROG controls on the argument structure test.

5.3.1 Change of state versus change of location verbs

Chapter 4 revealed that the typically developing children had more difficulties with change of state verbs than change of location verbs. It is therefore of interest whether children with SLI show the same pattern and whether they show the same or greater level of difficulty with change of state verbs.

The boxplot in Figure 5.2 shows the mean proportion of participants who used or chose the correct construction in the production and judgement tasks. All groups show lower scores on change of state verbs in both tasks and some ceiling effects for change of location verbs (particularly in the production task).

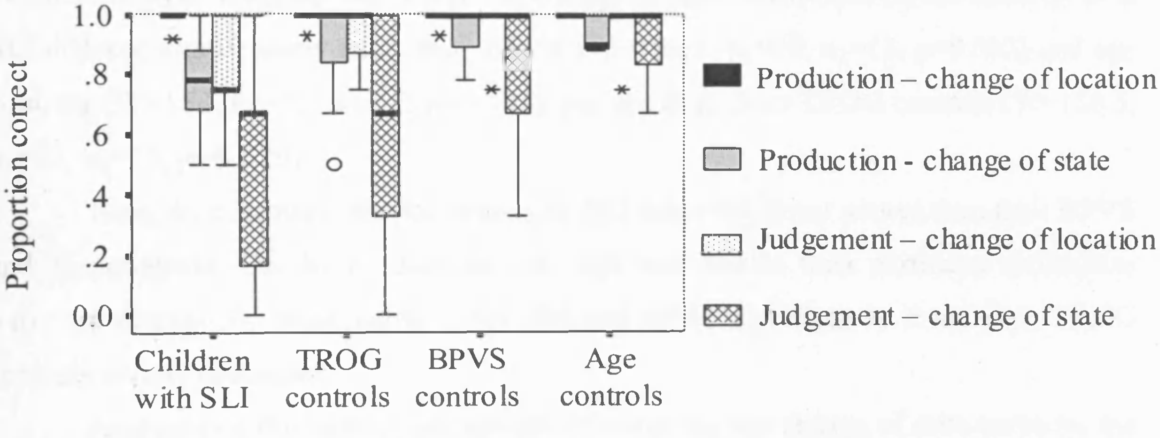


Figure 5.2: Proportion of participants using/choosing correct syntactic frame for change of location and change of state verbs in production and judgement tasks

Kruskal-Wallis tests showed a significant main effect of group overall for both production ($\chi^2(3)=12.27$, $p=0.04$) and judgement ($\chi^2(3)=15.90$, $p<0.001$). Planned Wilcoxon signed ranks tests showed that, the children with SLI did not differ from their TROG controls in either production ($W=181$, $n_1=15$, $n_2=15$, $p=0.033$) or judgement ($W=186$, $n_1=15$, $n_2=15$, $p=0.563$), but differed significantly on both tasks from their BPVS (production: $W=162.5$, $n_1=15$, $n_2=15$, $p=0.003$, judgement: $W=162.5$, $n_1=15$, $n_2=15$, $p=0.003$) and age controls (production: $W=158$, $n_1=15$, $n_2=15$, $p=0.002$, judgement: $W=148.5$, $n_1=15$, $n_2=15$, $p<0.001$). A Wilcoxon matched samples test revealed a main effect of verb type for both production ($T=6$, $n=35$, $p<0.001$) and judgement ($T=81.5$, $n=37$, $p<0.001$). The interactions between verb type and group were analysed by subtracting the scores on change of state verbs from those on the change of location verbs and performing a Kruskal-Wallis test to compare the groups on this subtracted score. This showed a significant interaction between group and verb type for production ($\chi^2(3)=13.65$, $p=0.03$), but not for judgement ($\chi^2(3)=3.97$, $p=0.26$).

The difference in performance on the production task on the two different types of verbs was analysed within each group using Wilcoxon matched samples tests. These showed that the difference between performance on change of state and change of location verbs was significant for all groups of children (SLI: $T=0$, $n=9$, $p<0.001$. TROG controls: $T=1$, $n=7$, $p=0.03$; BPVS controls: $T=3$, $n=8$, $p=0.03$).

Kruskal-Wallis tests were used to investigate the differences between the groups for each type of verb. These revealed a significant difference on the change of state verbs ($\chi^2(3)=13.24$, $p=0.002$) but not on change of location verbs ($\chi^2(3)=2.04$, $p=0.90$). Planned Wilcoxon signed ranks tests on change of state verbs showed the children with SLI differed significantly from their BPVS ($W=159.5$, $n_1=15$, $n_2=15$, $p=0.002$) and age controls ($W=158$, $n_1=15$, $n_2=15$, $p=0.001$), but not from their TROG controls ($W=180.5$, $n_1=15$, $n_2=15$, $p=0.029$).

Thus, in summary, the children with SLI achieved lower scores than their BPVS and age controls. On the production task, this was due to their particular difficulties with the change of state verbs. They did not differ significantly from their TROG controls on any measure.

Analyses of the individual patterns of errors for the change of state verbs for the children with SLI showed one child consistently used the change of location construction for both *fill* and *build* (e.g., "the lady is filling the sweets into the jar" and "the girl is building the bricks"). A further three children consistently used the change of location construction for *fill* only while another two did so for *cover* (e.g., "the lady is covering the scarf on her head"). Thus in total, 6 of the 15 children with SLI consistently used the change of location construction with at least one change of state verb. This is a much higher proportion than the control children (where only 2 out of 45 did so – the two youngest children, aged 5-6 years). Several other children with SLI produced non-alternating change of state verbs in both constructions indicating that they thought the verb could alternate. Five children used both constructions for *build*, two children did so for *cover* and three for *fill*. This was the more common type of error amongst the control children (see Chapter 4).

5.3.2 Use of verb alternations: dative and locative alternations

This section investigates the participants' willingness to use alternating verbs in both constructions associated with the dative and locative alternations and to establish any preferences they may have for a particular construction, either in general or for particular verbs and whether the children with SLI have similar preferences to their controls. Table 5.2 shows the mean use of the change of state construction for the locative alternation and the ditransitive construction for the dative alternation. Equal use of the two possible constructions for each alternation would result in a score of 0.50 on the construction shown in the table.

Table 5.2: Mean (SD) use of change of state construction for locative alternation and ditransitive construction for dative alternation

Construction	SLI	TROG	BPVS	AGE
Change of state construction (loc alt)	0.50 *(0.14)*	0.52 *(0.14)*	0.60 *(0.14)*	0.68 *(0.17)*
Ditransitive construction (dat alt)	0.27 *(0.22)*	0.53 *(0.25)*	0.43 *(0.24)*	0.57 *(0.30)*

A repeated measures 2x4 ANOVA (alternation x group) showed a significant main effect of alternation ($F(1,56)=12.26$, $p=0.001$, $\eta^2=0.18$) and a main effect of group ($F(3,56)=5.68$, $p=0.002$, $\eta^2=0.93$), but no significant interaction ($F(3,56)=2.19$, $p=0.10$, $\eta^2=0.11$). Planned comparisons of the children with SLI with the other groups showed a significant difference between the children with SLI and their age controls ($p<0.001$), but the differences between them and their TROG ($p=0.02$) and BPVS controls ($p=0.32$) did not reach significance. The children with SLI showed equal use of the change of state and change of location constructions for the locative alternation ($t(14)=0.02$, $p=0.99$, $d=0.01$), unlike the control children and adults (analysed in Chapter 4, section 4.3.2) who used the change of state construction more than the change of location construction. The children with SLI also differed from the control children and adults in that they used the ditransitive construction significantly less than the prepositional phrase construction for the dative alternation ($t(14)=4.05$, $p=0.001$, $d=2.09$), whereas the control children and adults used both forms equally (see Chapter 4).

Individual patterns of use of the two forms were also considered for the children with SLI. Table 5.3 shows very similar patterns of use of the change of state construction for the locative alternation to the control children. For the dative alternation, the children with SLI resemble the control children in their greater use of the ditransitive construction for the verb *give* than for the verb *pass*, however, they use the ditransitive construction less than the controls for both verbs.

Table 5.3: Variation across verbs in use of locative and dative alternations. Proportion of verbs in change of state construction (for locative alternation) or ditransitive construction (for dative alternation)

Alternation	Verb	SLI	TROG	BPVS	AGE
Locative alternation (change of state)	spread	0.07	0.07	0.04	0.04
	pack	0.24	0.33	0.34	0.37
	empty	0.56	0.67	0.67	0.62
	wipe	0.76	0.77	0.83	0.87
	peel	0.97	0.85	0.89	0.90
Dative alternation (ditransitive)	give	0.48	0.80	0.76	0.80
	pass	0.13	0.36	0.22	0.48

5.3.3 Use of verb alternations: causative alternation

When using the causative alternation, the children's responses were considered in terms of whether they used the construction (intransitive or transitive) which matched the transitivity of the video scene shown. Figure 5.3 shows the proportion of children who used the matching construction for alternating verbs. This shows that all children tended to use the matching construction less for intransitive than transitive scenes. The children with SLI seemed to be performing more similarly to their age than language controls.

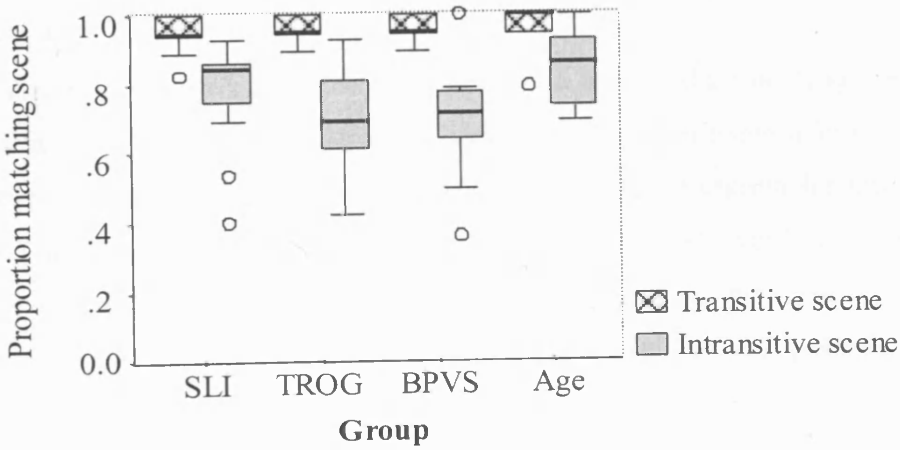


Figure 5.3: Use of construction which matches video scene

Due to the strong ceiling effect for transitive scenes, non-parametric statistics were used for analyses involving these measures. The main effect of scene was analysed using Wilcoxon matched pairs tests and showed a significant effect where the matching construction was less likely to be used for intransitive scenes ($T=62$, $n=58$, $p<0.001$). Scores averaged over both conditions were analysed in a Kruskal-Wallis test and showed no main effect of group ($\chi^2(3)=6.00$, $p=0.11$). The interactions between scene type and group were analysed by subtracting the scores on intransitive scenes from those on transitive scenes and performing a Kruskal-Wallis test to compare the groups on this subtracted score. This showed a significant interaction between group and scene type ($\chi^2(3)=9.32$, $p=0.02$). This interaction was further investigated by considering the effect of group on each scene type separately; a Kruskal-Wallis test showed no effect of group for transitive scenes ($\chi^2(3)=1.58$, $p=0.67$) but a one-way ANOVA (as the data were normally distributed) showed a marginally significant group effect for intransitive scenes ($F(3,56)=2.93$, $p=0.042$, $\eta^2=0.14$). Planned pairwise comparisons showed no difference between the SLI group and their TROG ($t(28)=1.45$, $p=0.16$, $d=0.52$), BPVS ($t(28)=0.79$, $p=0.44$, $d=0.31$), or age controls ($t(28)= -1.60$, $p=0.12$, $d= -0.49$). The significant overall effect may therefore be due to differences between the control groups.

Schelletter et al. (1998) found that only children with SLI with poor ability to use the past tense correctly differed from their age controls on the causative alternation. All children in this study were tested on the VATT. Within the control children over the age of 8 years, the minimum score on the past tense section was 14/20. Only one child with SLI scored at this level. Therefore the sample in this study is likely to be similar to the group in Schelletter et al.'s (1998) study who were poor at the past tense. The difference between the findings of the two studies will be addressed in the discussion (section 5.4.1).

Figure 5.4 shows the children's ability to choose the matching construction in the judgement task. The main effect of scene was analysed using a Wilcoxon matched pairs test; the matching construction was less likely to be chosen for intransitive than transitive scenes ($T=78.5$, $n=41$, $p<0.001$). Scores averaged over both conditions were analysed showing no main effect of group ($\chi^2(3)=3.74$, $p=0.30$). The interaction between scene type and group was also not significant ($\chi^2(3)=2.57$, $p=0.46$).

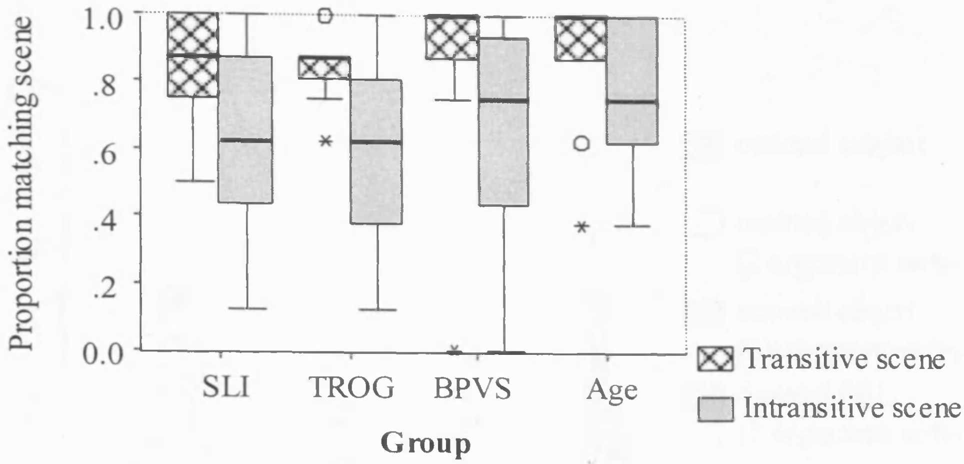


Figure 5.4: Choice of construction in judgement task which best matches scene

In summary, the children with SLI did not differ significantly from controls in their ability to produce or judge alternating verbs in the causative alternation.

5.3.4 Obligatory arguments

Omission of obligatory arguments was initially analysed by comparing the groups on the total number of omitted obligatory arguments of any type (using a Kruskal Wallis test due to the strong floor effect in the BPVS and age controls). This revealed a significant difference between the groups ($\chi^2(3)=10.72$, $p=0.01$). Planned (Wilcoxon signed rank) comparisons showed the children with SLI omitted significantly more obligatory arguments than their BPVS controls ($W=171$, $n_1=15$, $n_2=15$, $p=0.01$), but not than their TROG ($W=198$, $n_1=15$, $n_2=15$, $p=0.16$) or age controls ($W=188$, $n_1=15$, $n_2=15$, $p=0.06$).

The boxplot in Figure 5.5 shows the proportion of obligatory arguments omitted for each group, split by argument type. A Friedman test showed that the children with SLI omitted different proportions of arguments according to their type ($\chi^2(2)=59.4$, $p<0.001$). Post-hoc Wilcoxon matched samples tests showed this was due to a significant difference between the proportion of omitted subjects and obligatory objects ($T=36.5$, $n=23$, $p=0.001$), subjects and obligatory prepositional phrases ($T=6$, $n=41$, $p<0.001$) and obligatory objects and prepositional phrases ($T=0$, $n=39$, $p<0.001$). Thus, the children with SLI differed in their patterns of omissions from the control children (in Chapter 4) who showed no significant difference in their omission of subjects and obligatory objects, but were similar in that they omitted the most prepositional phrases.

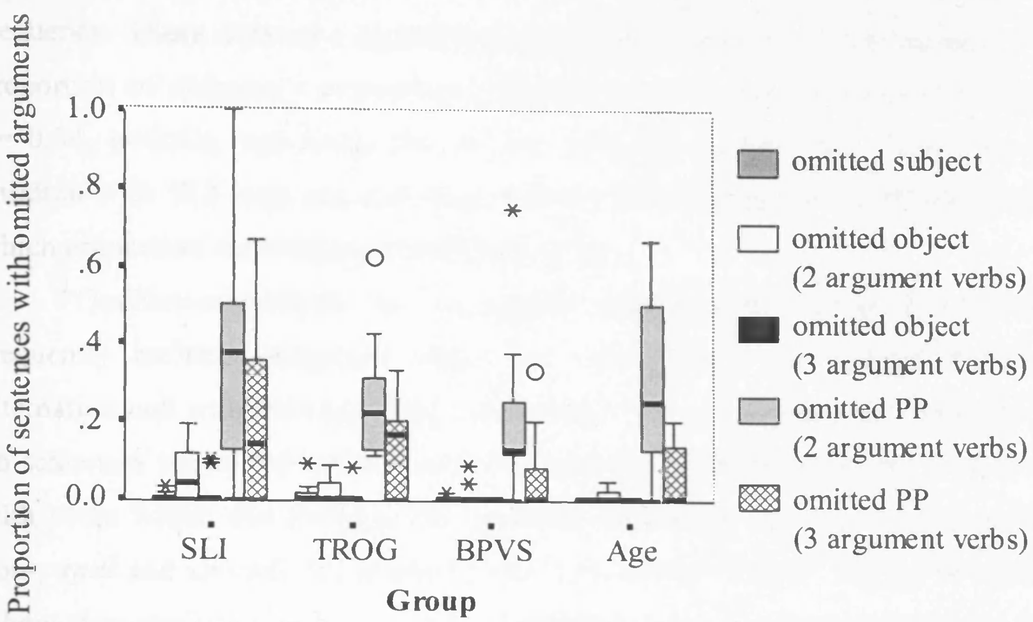


Figure 5.5: Proportion of arguments omitted

Kruskal-Wallis comparisons across groups for each argument type showed a significant difference in the proportion of omitted subjects ($\chi^2(3)=8.1$, $p=0.04$) and objects ($\chi^2(3)=13.1$, $p=0.004$), but no difference for prepositional phrases ($\chi^2(3)=4.7$, $p=0.19$). Planned Wilcoxon signed ranks comparisons showed the SLI group did not differ from any of their control groups on omission of subjects ($p>0.2$), but they did differ on omissions of objects from their BPVS ($W=167$, $n_1=15$, $n_2=15$, $p=0.002$) and age controls ($W=168$, $n_1=15$, $n_2=15$, $p=0.004$); they did not differ from their TROG controls ($W=187.5$, $n_1=15$, $n_2=15$, $p=0.06$).

Most theories of SLI predict that children with SLI should omit more arguments than controls where more arguments are required, because such sentences are longer and more complex. Therefore, the children with SLI were compared with their controls on the omission of arguments for verbs which require two versus three arguments. Kruskal-Wallis tests showed that the groups did not differ on their omission of arguments from verbs requiring two arguments ($\chi^2(3)=5.9$, $p=0.12$), but did differ on verbs requiring three arguments ($\chi^2(3)=10.6$, $p=0.01$). Planned Wilcoxon signed ranks comparisons showed this was due to differences between the children with SLI and their BPVS ($W=174$, $n_1=15$, $n_2=15$, $p=0.008$) and age controls ($W=174$, $n_1=15$, $n_2=15$, $p=0.009$); they did not differ significantly from their TROG controls ($W=192$, $n_1=15$, $n_2=15$, $p=0.010$).

Omission of obligatory prepositional phrases and objects by children with SLI were analysed with Spearman rank correlations (1-tailed) of rate of omissions with verb frequency. These showed a significant negative correlation of verb frequency with the proportion of obligatory prepositional phrases ($r=-0.75$, $p=0.001$) and objects omitted ($r=-0.34$, $p=0.02$), indicating that in line with the controls (see section 4.4.2), the children with SLI may use statistical evidence and / or parental feedback in learning which arguments are obligatory for which verbs.

Qualitative analyses for the control subjects (see Chapter 4) revealed they frequently omitted obligatory objects in verbs which can undergo the causative alternation and with the verb *build*, where they omitted non-prototypical objects. Of the 26 sentences where the children with SLI omitted an obligatory object, 14 (53%) were with verbs which can undergo the causative alternation: *empty, fill, hang, melt, peel, pour, spill* and *spread*. These errors were very similar to those of the control children where they produced an intransitive construction but with an Agent in subject position rather than the Theme, as if they were transitive with an optional object, e.g., "the man is melting". Again, this implies that, like the controls, they are unaware that use of the intransitive construction with these verbs changes the thematic role of the subject to Patient/Theme. This could be because they are unaware that these verbs can detransitivise; indeed, in section 5.3.3 I found evidence of failure to use detransitivisation, similar to the controls in Chapter 4.

Children with SLI omitted *car* and *tower* with the verb *build* to a similar degree as the controls (3 out of 29 attempts for children with SLI and 2 out of 29 or 30 attempts for each of the control groups). In common with two of the controls, four children with SLI omitted the object with the verb *fill* in the Agent-less scene: "the water is filling (up)", where the target should have been either *the water is filling the sink* or *the sink is filling (up)*. As discussed in Chapter 4, this verb is particularly difficult, as in the intransitive construction the Goal (not the Theme) must be in the subject position, unlike most other alternating verbs. If the Theme is in the subject position with this verb, the transitive construction needs to be used.

The children with SLI also omitted objects on the verbs *cover, put* and *wipe*. These errors did not occur for the control children. Three of these errors were simple omissions: "she's been covering with a cloth", "the lady is putting on the table", "she is wiping on the mat". The other two errors were more complex as the object was mentioned, but in a prepositional phrase: "the lady is covering on her hair" and "the man is wiping on the table". It is not clear in either case whether the child has added a preposition before the object or whether he has attempted to use the verb in the change of location construction (ungrammatically for *cover*), but has then omitted the object of this construction.

5.4 Discussion

The results indicate that children with SLI generally have more difficulties with argument structure than their vocabulary and age controls. However, more specific analyses show that they differ only in some areas: namely production and judgement of change of state verbs, use of the ditransitive construction, omission of arguments with verbs requiring three arguments and omission of obligatory objects. The lack of difference from their TROG controls may be accounted for by the fact that argument structure in general is correlated with scores on the TROG, both for the controls and children with SLI. This could be because some aspects of the learning of argument structure (especially reverse linking) rely on syntactic abilities and the TROG relies on some of the same abilities.

The analyses of the change of state verbs revealed that the children with SLI achieved similar scores to their TROG controls but made more errors on both the production and judgement tasks than their age and vocabulary controls. However, the individual analyses showed that 40% of the children with SLI consistently used the incorrect construction for at least one verb compared to only 4% of the controls (the two 5 year olds). In Chapter 4, I argued that children who use change of state verbs exclusively in the change of location construction may be basing their semantic representations of the verb on observation alone and may not be using syntactic bootstrapping.

In Chapter 2, I argued that children could refine their semantic representations of these verbs by two methods (either separately or in tandem): they could use syntactic bootstrapping to predict the thematic core of the verb from the adult syntax, or they may observe events described by the verb which do not exactly match their stored representation for the verb. For example, if their stored meaning for *fill* is similar to *pour*, they may think it involves a particular manner of motion and hence have assigned it to the incorrect narrow conflation class. If they observe a *filling* action which differs in this respect (for example *filling* something by moving objects by hand rather than by pouring) then they could delete the unnecessary meaning component involving the manner of motion. However, the children may then hypothesise that the verb can occur in both the change of location and change of state constructions and therefore need to restrict the verb only to the change of state construction. They could do this by identifying the full meaning of the verb (by adding the change of state meaning component to the semantic representation) and thus assigning it to the correct narrow conflation class and allowing narrow range rules to prevent the verb from alternating. However, marking a component of meaning as obligatory is difficult without negative evidence. The child could achieve this by using statistical evidence whereby the more often a meaning component is observed to co-occur with an event described by a particular verb, the more likely it is to be an obligatory part of that verb's meaning. Alternatively, adults could provide them with implicit feedback or explicit instruction regarding the meaning of the verb and/or the constructions in which it can and cannot appear.

Given the mechanisms described above, several methods could be predicted to improve the performance of children with SLI on change of state verbs. Some of these involve increasing the frequency of cues which are normally available in the input (but dispersed across time), whereas others involve providing feedback or instruction to the children which may be implicitly available in the course of typical learning, but these could also be made explicit to ensure that the children have noted the relevant cues; such explicit feedback does not typically occur during adult/child interactions. However, it could be argued that where children with SLI continue to have specific difficulties with particular areas of language well beyond the age at which they would normally be mastered, additional cues may be required and these may need to be made explicit. Possible methods could involve:

1. Providing multiple observations of events, some of which do not involve the prototypical motion of the Theme (so that this component of meaning is deleted)
2. Informing the child of the necessary and unnecessary meaning components of the verb's semantic representation. This could be done implicitly (through contrastive feedback) and /or explicitly
3. Informing the child (explicitly or implicitly) when an event cannot be described with a particular verb
4. Focusing on the change of state of the Patient
5. Focusing the child's attention on the construction used by the adult so that he/she can use syntactic bootstrapping to infer the thematic core of the verb
6. Providing multiple examples of the correct construction so that the child can assume on the basis of statistics that the alternative construction is disallowed

7. Provide implicit or explicit negative evidence by 'informing' the child that he/she cannot use the change of location construction with these verbs.

These methods will be tested in Chapter 9 (using both implicit and explicit information) where one group of children with SLI will be taught using components 1-4; these should refine their semantic representations (both the thematic core and the details of the semantic representation which can be used as input to narrow range rules) but do not use syntactic bootstrapping. Another group will be taught using components 4-7 where the focus is on the syntax and how this links to the thematic core, but no focus is placed on those components of meaning which affect the application of narrow range rules. In theory, both of these groups should improve their production of change of state verbs. This hypothesis will be tested in Chapter 9.

5.4.1 Alternations

The children with SLI showed little difference from their controls in their use of the locative and causative alternations. For the locative alternation, they showed a similar pattern of use of the two alternative constructions for individual verbs, but showed a tendency to use the change of state construction less than their typically developing peers (who used this construction more than the change of location construction). They did not differ from controls in their production or judgement of the causative alternation with alternating verbs. This concurs with the findings of Loeb et al. (1998) but diverges from those of Schelletter et al. (1998) who found that children with SLI with poor past tense morphology used the causative alternation less than age controls. However, Schelletter et al. measured the use of alternations differently from this study as they counted whether each child used both constructions involved in the alternation on at least one occasion regardless of the video scene. The lack of significant difference from controls in this study should not be interpreted as showing that the children with SLI had no difficulties with the causative alternation. The reason for the lack of difference lies instead in the unexpected difficulties which the *control* children showed in using the intransitive construction with alternating verbs.

The children with SLI showed a very different pattern of use of the dative alternation. As a group they used the prepositional construction rather than the ditransitive construction (unlike the controls who showed no such difference). Their pattern of performance is thus similar to that found in typically developing 3 to 5 year olds (Osgood & Zehler, 1981) and tallies with Thordardottir and Weismer's (2002) finding that children with SLI use the ditransitive construction less than their language controls in their spontaneous speech. However, in common with their controls, they did use the ditransitive construction more with the verb *give* than *pass*. The reason for their preferential use of the prepositional construction is not clear from this study as those children who did use the ditransitive construction, used it accurately.

5.4.2 Omission of obligatory arguments

Investigations of participants' omissions of obligatory arguments revealed that the children with SLI omitted more arguments in verbs requiring three arguments and omitted more obligatory objects than their vocabulary and age controls. Thordardottir and Weismer (2002) also reported that children with SLI omit more arguments in spontaneous speech than age controls but found they were no different from language controls matched on mean length of utterance (MLU). Watkins and Rice (1991) however, found that children with SLI omitted more objects in their spontaneous speech than both their age and MLU controls.

In this study, the children with SLI did not omit more subjects than controls and, in contrast to Grela and Leonard's (1997) finding with spontaneous speech, they omitted no subjects with unaccusative verbs. However, this difference may be due to the nature of my elicitation task where the children were encouraged to use subjects in the practice items. The children with SLI in this study also omitted more prepositional phrases than objects or subjects but did not differ from controls in this respect.

Qualitative analysis of omission of obligatory objects showed some similarities and some differences between the children with SLI and controls. All groups omitted more objects in verbs which can undergo the causative alternation, indicating a lack of awareness that using the intransitive construction with these verbs alters the thematic role of the subject. The children with SLI also omitted more objects with transitive verbs in general. In these cases, they produced both a subject and prepositional phrase and omitted the object. It is therefore possible that they have difficulty producing sentences with three arguments or that they have simply failed to mark these arguments as obligatory.

One of the groups of children in the intervention study in Chapter 9 will receive explicit instructions about which arguments are optional versus obligatory with particular verbs and will be given a visual support system to remind them of the necessity to produce all three arguments for some verbs. The other group will not be told which participants are obligatorily expressed as arguments, but intervention will focus on all relevant aspects of the events described by the verbs, thus ensuring that they are aware of all the participants in the event and thus all potential arguments of the verb. If the difficulty is with marking arguments as obligatory, it is predicted that the group receiving explicit information regarding this will show a greater reduction in their omissions of obligatory arguments compared to the other group.

5.4.3 Summary of findings and implications for intervention

Let us now summarise those areas where the children with SLI did and did not differ from their controls and therefore make inferences as to where intervention is needed. They do not require intervention for those areas where they did not differ significantly from any control group. These areas were:

- Use and judgement of the causative alternation.
- Their ability to use and judge the correct construction for change of location verbs.
- Omission of obligatory subjects and prepositional phrases

The children with SLI differed from both their age and vocabulary (BPVS) controls, but not from their sentence comprehension (TROG) controls on some areas. These areas should be targets for intervention as the children with SLI are performing below the level of their vocabulary knowledge. These areas of specific difficulty are:

- Overall argument structure score
- Use of the incorrect construction for change of state verbs
- Omission of arguments for verbs requiring three arguments
- Omission of obligatory object arguments

The children with SLI performed differently from *all* control groups in only two areas: they showed different choices in their use of the dative alternation and made more consistent errors with change of state verbs. These areas should then be highest priority for intervention as the children with SLI show very specific weaknesses in these areas. However, their choice of the prepositional form of the dative alternation does not affect their ability to communicate and is therefore lower priority. However, this weakness may also extend to comprehension. If this is the case, then it is of more concern and needs to be investigated and intervention provided (see Ebbels et al., 2002 for three case studies of intervention for comprehension of the dative alternation). Difficulties with change of state verbs however are high priority, especially given that six children with SLI (aged 11;0 to 14;11) made consistent errors of the kind only made by the 5 year old control children.

5.4.4 Implications for theories of SLI

The predictions of theories of SLI as regards argument structure were discussed in section 2.3.1. Some theories make no predictions with regard to argument structure (the Feature Blindness, Agreement Deficit, Extended Optional Infinitive and Temporal Processing Deficit hypotheses) and therefore cannot account for the results of this chapter. Other theories can account for difficulties with argument structure, but propose different underlying reasons (processing difficulties or difficulties using syntactic or phonological bootstrapping). These theories would all predict the correlations that were found between argument structure and sentence comprehension (TROG) and formulation (Formulated Sentences) but differ in the other correlations they predict. Underlying difficulties with slow processing, limited processing capacity or limited phonological short-term memory would all predict correlations between argument structure and phonological memory measures. The Phonological Mapping hypothesis would predict correlations with phonological measures. In contrast, the Representational Deficit for Dependent Relations hypothesis is neutral regarding correlations with measures of phonology or short-term phonological memory. Therefore, in order to be able to distinguish between these theories, we need to investigate the relationship between argument structure performance and measures of phonological abilities or short-term memory. Non-word repetition tasks have been used in the past to infer both phonological (Edwards & Lahey, 1998; Gallon et al., 2005, ms) and short-term memory abilities (Gathercole & Baddeley, 1990). Therefore, Chapter 6 will investigate the performance of the children on a non-word repetition test and the relationship between performance on this task and the argument structure test of this chapter. I will use a non-word repetition test (the Test of Phonological Structure, van der Lely & Harris, 1999) which allows us to investigate whether any difficulties with this task are due to phonological structural and prosodic difficulties per se or difficulties with phonological short-term memory.

5.5 Conclusions

Children with SLI have general difficulties with argument structure, particularly when compared with vocabulary and age controls. The areas of most significant difference are their apparent avoidance of the ditransitive construction and the consistent use of the change of location construction for change of state verbs by more than a third of the children with SLI, a pattern seen only in the youngest control children, aged 5-6 years. They also differ from controls in that they omit more obligatory arguments. These results point to the need for intervention for change of state verbs and omission of obligatory arguments. Possible methods of intervention have been discussed and these will be evaluated in Chapter 9.

CHAPTER 6 INVESTIGATING THE ROLE OF PHONOLOGY AND SHORT-TERM MEMORY IN SPECIFIC LANGUAGE IMPAIRMENT USING A NON-WORD REPETITION TASK

6.1 Introduction

Many studies have found that children with SLI have severe difficulties repeating non-words relative to age (or mental age)-matched controls (Kamhi & Catts, 1986; Kamhi et al., 1988; Bishop et al., 1996; Dollaghan & Campbell, 1998; Edwards & Lahey, 1998; Ellis Weismer et al., 2000), language-matched controls (Montgomery, 1995a; 1995b; Edwards & Lahey, 1998) or both (Gathercole & Baddeley, 1990; Briscoe et al., 2001; Montgomery, 2004). Indeed, difficulty with non-word repetition (particularly of longer words) has been suggested as a clinical marker for SLI (see Chapter 1). Some *processing* theories of SLI claim that particular deficits underlying these non-word repetition difficulties *cause* SLI. Gathercole & Baddeley (1990) propose the underlying deficit is a limited phonological short-term memory capacity. Others suggest the difficulty is with forming phonological representations, either because of difficulties perceiving sounds (Joanisse & Seidenberg, 1998), possibly as a result of difficulty processing brief acoustic cues (Tallal & Stark, 1981) or identifying phonological details in rhythmic structure (Chiat, 2001). Theories which focus on limited processing capacity (Leonard et al., 1992a; Leonard, 1998) or slowed general processing (Bishop, 1994a) predict children with SLI should have more difficulties with tasks involving greater processing demands, including longer and more complex words on non-word repetition tasks or those involving phonetically weak information such as word final consonants or unstressed syllables. However processing difficulties would also affect performance on other language measures. Thus, processing theories predict a relationship between performance on non-word repetition tasks and other language tasks.

Most *linguistic* theories on the other hand claim no direct link exists between difficulties with non-word repetition and other morpho-syntactic difficulties. These would not therefore predict correlations between performance on non-word repetition tasks and other language tests. They would also predict that it should be possible to find children with SLI who have no difficulties with non-word repetition tasks. Thus, investigations of the performance of children with SLI on non-word repetition tasks and the relationship of this to other language tasks can shed light on the debate between processing and linguistic theories.

Several studies have found overlaps in the scores of children with SLI and controls, indicating that some children with SLI do not have non-word repetition difficulties (Montgomery, 1995b; Bishop et al., 1996; Edwards & Lahey, 1998). Comparisons of the performance in other language areas of those children with SLI who do versus those who do not have difficulties with this task would provide valuable information regarding the nature of any link between non-word repetition and other language abilities. One such study (Botting & Conti-Ramsden, 2001) has been carried out, but those children who scored well on the non-word repetition tests did not meet the standard criteria for SLI as they scored above the 25th percentile on all language measures. Studies investigating correlations between performance on non-word repetition tasks and other areas of language in children with SLI have reported conflicting findings (see Chapter 1, section 1.8). This chapter therefore examines whether all children in a clearly defined group of children with SLI have difficulties on a non-word repetition task and then investigates the relationship between their performance on this area and other language areas.

Because repeating non-words is a complex task involving many processes (see Chapter 1, section 1.8), children could have difficulties for many reasons. The most commonly cited are short-term phonological memory as shown by poorer performance with longer non-words (Gathercole & Baddeley, 1990; Gathercole, Willis, Emslie & Baddeley, 1991; Montgomery, 1995b; Ellis Weismer et al., 2000; Briscoe et al., 2001) and phonological or articulatory difficulties as shown by poorer performance on words containing consonant clusters (Bishop et al., 1996; Briscoe et al., 2001). The stress pattern of non-words has also been found to affect performance where children perform worse on words with a Weak Strong (WS) stress pattern than a Strong Weak (SW) pattern (Sahlen et al., 1999). A study using the Test of Phonological Structure (TOPhS, van der Lely & Harris, 1999) specifically examined phonological complexity including stress patterns and found that children with SLI were detrimentally affected by increasing complexity (Gallon et al., 2005, ms).

The studies of non-word repetition in the literature do not allow us to identify which of the proposed factors underlie difficulties with non-word repetition as not all these factors have been considered together in one study. It is particularly important to compare these factors directly as several of them interact with each other. For example, longer words often have a more complex stress pattern (or 'metrical structure'). Until we have a clearer understanding of which features of the non-words cause difficulties (e.g., length versus metrical structure), we cannot begin to make claims about the underlying psychological reasons for these difficulties (e.g., short-term memory versus difficulties with complex phonological structures). This chapter aims to investigate the effects of both length and phonological complexity in children with SLI and typically developing controls. In order to maximise comparisons with other studies, I will consider phonological complexity both in terms of stress patterns (metrical structure) and at the level of the syllable (for example, the effects of consonant clusters). No test of non-word repetition is designed specifically to look at all of these factors. However, the TOPhS (van der Lely & Harris, 1999) considers phonological complexity in detail and unlike most other tests includes both metrical and syllable structure and their interactions. Therefore I will use this test and also consider length by counting the number of syllables in each non-word.

The TOPhS consists of ninety-six non-words which are derived from four basic non-words /dɛ́pə, pífi, fípl̩, kɛ́tə/, with the simplest stress pattern (Strong Weak – SW) and no consonant clusters, thus fitting the template CVCV. The 24 non-words based on the basic non-word 'depe' are shown in Table 6.1. The variants of the basic non-words were constructed using five binary phonological parameters, three of which control aspects of 'syllabic structure' and two of which control aspects of 'metrical structure' (involving stress patterns). Each parameter has two options: marked or unmarked. The unmarked structure occurs in all languages and appears early in the phonological acquisition process whereas the marked structure occurs only in a subset of languages and is acquired relatively late.

Of the three parameters controlling syllable structure, one establishes whether an ***onset*** contains one consonant (unmarked, e.g., /**d̲**ɛ́pə/) or more than one consonant (marked, e.g., /**d̲r̲**ɛ́pə/). Another determines whether a ***rhyme*** is open, i.e. ends in a vowel (unmarked e.g., /d**ɛ̲́**pə/) or is closed, i.e. ends in a consonant (marked e.g., /d**ɛ̲́m̲**pə/). A third establishes whether a ***word end***s in a vowel (unmarked, e.g., /dɛ́p**ə̲**/) or a consonant (marked, e.g., /dɛ́p_/). Of the two parameters controlling metrical structure, one establishes whether a word contains a weak syllable adjoined to the beginning of a word (***Left Adjunction***) and the other whether a weak syllable is adjoined to the end of a word (***Right Adjunction***). In both cases, adjunction adds to the metrical complexity of a word and constitutes the marked option. Left Adjunction leads to the marked stress patterns WSW (e.g., /**b̲ə̲**dɛ́pə/) or WS (e.g., /**b̲ə̲**dɛ́p/) and Right

Adjunction to the marked pattern SWW (e.g., /dɛ́pə**ri**/). Words with both Left and Right Adjunction are the most complex metrically and have the marked stress pattern WSWW (e.g., /**bə**dɛ́pə**ri**/).

Table 6.1: Structure of the TOPhS test (van der Lely & Harris, 1999); u=unmarked, m=marked

	Syllable parameters				Metrical parameters			Total	Number
TOPhS non-word	Onset	Rhyme	Word End	Number marked	Left Adj	Right Adj	Number marked	marked structures	of syllables
d e p e	u	u	u	0	u	u	0	0	2
dr e p e	m	u	u	1	u	u	0	1	2
d e **mp** e	u	m	u	1	u	u	0	1	2
d e p _	u	u	m	1	u	u	0	1	1
be d e p e	u	u	u	0	m	u	1	1	3
d e p e **ri**	u	u	u	0	u	m	1	1	3
dr e **mp** e	m	m	u	2	u	u	0	2	2
dr e p _	m	u	m	2	u	u	0	2	1
d e **mp** _	u	m	m	2	u	u	0	2	1
be **dr** e p e	m	u	u	1	m	u	1	2	3
dr e p e **ri**	m	u	u	1	u	m	1	2	3
be d e **mp** e	u	m	u	1	m	u	1	2	3
d e **mp** e **ri**	u	m	u	1	u	m	1	2	3
be d e p _	u	u	m	1	m	u	1	2	2
be d e p e **ri**	u	u	u	0	m	m	2	2	4
dr e **mp** _	m	m	m	3	u	u	0	3	1
be **dr** e mp e	m	m	u	2	m	u	1	3	3
dr e **mp** e **ri**	m	m	u	2	u	m	1	3	3
be **dr** e p _	m	u	m	2	m	u	1	3	2
be d e **mp** _	u	m	m	2	m	u	1	3	2
be dr e p e **ri**	m	u	u	1	m	m	2	3	4
be d e **mp** e **ri**	u	m	u	1	m	m	2	3	4
be **dr** e **mp** _	m	m	m	3	m	u	1	4	2
be **dr** e **mp** e **ri**	m	m	u	2	m	m	2	4	4

The five parameters of the TOPhS (Onset, Rhyme, Word End, Left Adjunction and Right Adjunction) allow us to look at the effects of phonological complexity in general (by counting how many of these five parameters are 'marked'), or just at 'syllabic complexity' (counting how many of the three syllable parameters - Onset, Rhyme and Word End - are 'marked') or 'metrical complexity' (counting how many of the two metrical parameters - Left and Right Adjunction - are 'marked'). In order to analyse the effect of length, the number of syllables in each word were also counted. Table 6.1 shows which parameters are marked (hi-lighted in bold and underlined in non-word) and also gives a count for overall phonological complexity (total marked structures), syllabic complexity (number of marked syllable structures) and metrical complexity (number of marked metrical structures) as well as the number of syllables.

This chapter will consider the ability of a group of children with SLI to repeat the non-words in the TOPhS test and examine the relationship between performance on this test and other language measures. This should shed light on the relationship between non-word repetition and other deficits in SLI and hence the ability of current processing and linguistic theories to account for the profiles of children with SLI. It will also consider the effects of length and a variety of phonological complexity measures on the performance of both the children with SLI and controls, aiming to establish the underlying reasons for any difficulties with the task.

6.2 Aims of Chapter

This chapter aims to answer the following research questions: -

- Do *all* children with SLI show evidence of phonological or short-term memory deficits as measured on a non-word repetition test compared with control children matched for age, sentence understanding or vocabulary?
- Is performance on the non-word repetition test related to performance on tests measuring morphology, syntax, vocabulary or argument structure?
- Is performance affected by length or measures of phonological complexity? (i.e., are difficulties due to a short-term memory or phonological deficit?)

6.3 Methods

The participant details, selection and matching criteria are all described in Chapter 3, as are the tests referred to in this chapter. These consist of standardised language (CELF-3, BPVS, TROG) and non-verbal tests (Matrices and Pattern Construction subtests of the BAS-II) and also non-standardised language tests (the VATT – described in Chapter 3 and the test of argument structure of Chapters 4 and 5).

Testing was carried out in a quiet room in the participants' schools. For the TOPhS test, the children were told they would hear some "funny, made up words", which they should try to repeat into a microphone. The list of non-words was audio recorded by a female native English speaker using a Bruel and Kjaer sound level meter (model 2231). A 3 second silent interval occurred after each non-word. The children heard the digitally recorded non-words via Sennheiser AD475 headphones and their repetitions were recorded onto a DAT tape (TCD-D8) via an external Sony Electret condenser microphone. The non-words were presented continuously without a break in a set random order. Repetitions were transcribed on-line and subsequently verified against the recording. Inter-rater reliability was computed by comparing the transcriptions for four children with SLI with those of an independent transcriber working from the digital recording. Children with SLI were used for reliability testing as they made more errors than controls and were also deemed more difficult to transcribe. Phoneme by phoneme inter-rater agreement for these four transcriptions was 99%.

6.4 Results[8]

Each non-word was scored either as correct or incorrect. Table 6.2 shows the mean, standard deviation and range of scores for the four groups of children. The results for the individual children are shown in Appendix D.

Table 6.2: Mean number of TOPhS non-words repeated correctly (96 non-words in total)

Group	Mean *(SD)*	Range	
SLI	60.4 *(22.4)*	32-89	
TROG controls	81.7 *(9.1)*	61-94	
BPVS controls	84.2 *(9.2)*	64-95	
AGE controls	87.0 *(7.5)*	64-96	(without outlier: 82-96)

In line with previous studies involving non-word repetition tests, a one-way ANOVA showed a significant effect of group ($F(3,56)=12.05$, $p<0.001$, $\eta^2=0.39$) and post-hoc Bonferroni corrected t-tests showed this was due to a significant difference between the SLI group and the three control groups ($p<0.001$, $d>1.58$) and that the control groups did not differ from each other ($p=1.0$, $d>0.39$).

However, tests of normality (Shapiro-Wilk) showed that the above test is invalid as the scores for both the age controls and the SLI group deviated significantly from normality (Age: $p=0.003$, SLI: $p=0.03$). In the case of the age controls this was due to one outlier who scored significantly lower than the others. When this score was removed, their data were normally distributed ($p=0.30$). The presence or absence of his score made no difference to the significance of any of the tests, so his scores were included in all analyses. In the case of the children with SLI, a histogram (Figure 6.1) shows the deviation from normality is due to a bi-modal distribution where no child scored between 47 and 68.

The children with SLI therefore cannot be considered to be one homogeneous group. For this reason they were split into two groups on the basis of their scores on the TOPhS: 'SLI-high' (8 children, mean: 79, SD: 9.3) and 'SLI-low' (7 children, mean:

[8] Preliminary analyses of the results of this chapter were presented at the Boston University Conference on Language Development, October 2003.

39, SD: 6.2). Shapiro-Wilk tests on these two groups were non-significant. These smaller groups will be used for all further analyses in this chapter.

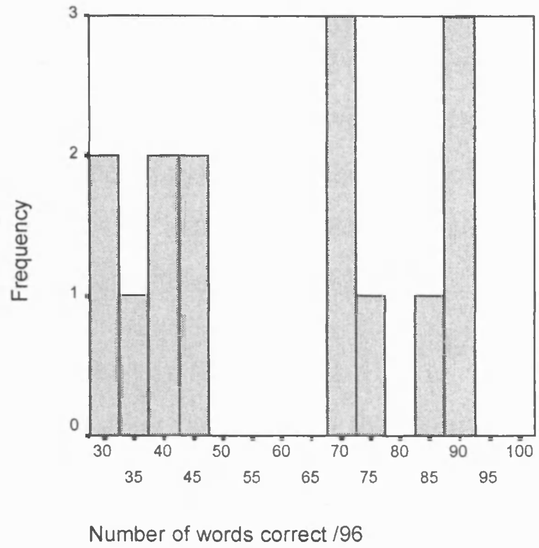


Figure 6.1: Histogram showing bi-modal distribution of SLI scores on TOPhS test

A boxplot (Figure 6.2) of TOPhS scores for the five groups of children shows the SLI-low group achieved much lower scores on the TOPhS than any of the other groups. Indeed there was no overlap at all between the SLI-low group and the other groups. In contrast, the SLI-high group achieved similar scores to all control groups.

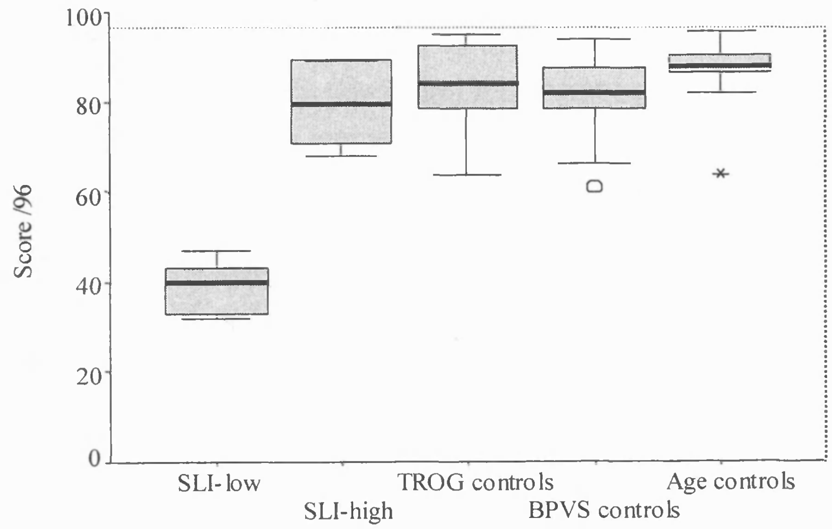


Figure 6.2: Boxplot showing distribution of TOPhS scores (/96) for SLI-low, SLI-high, language and age controls

The TOPhS scores of each of the two SLI groups were compared with those of their individually matched controls using one-way ANOVAs with Group as the between subjects variable (SLI, TROG, BPVS, Age). When comparing the 'SLI-high' group with their individual matches, no significant effect of Group was found ($F(3,28)=0.81$,

$p=0.50$, $\eta^2=0.08$). In contrast, a highly significant effect of Group was found for the 'SLI-low' group and their individually matched controls ($F(3,24)=98.28$, $p<0.001$, $\eta^2=0.93$). Post-hoc Bonferroni corrected tests showed that this was due to a highly significant difference between the 'SLI-low' group and all their control groups ($p<0.001$, $d>6.97$) and no difference between control groups ($p>0.3$, $d<1.10$). This is particularly striking when we consider the ages of the children: the SLI-low group ranged in age from 11;4 to 14;8 and all scored well below the youngest control (age: 5;4, score: 66) despite being 6 to 9 years older.

6.4.1 Comparison of the two SLI groups

To investigate further the nature of the differences between the two SLI groups, their TOPhS scores, ages, raw and z-scores on a range of standardised tests were compared using t-tests (or Wilcoxon signed ranks tests for non-normally distributed data). The two groups differed significantly in TOPhS scores ($t(12.2)=10.1$, $p<0.001$, $d=5.08$) but not in age ($t(13)=-0.49$, $p=0.63$, $d=0.25$). Comparisons of the two SLI groups on the standardised tests revealed no significant differences between the two groups on any of the raw or z-scores (BAS: $t(13)=0.37$, $p=0.72$, $d=0.19$; CELF-3 Receptive Language: $W=48.5$, $n_1=7$, $n_2=8$, $p=0.42$; CELF-3 Expressive Language: $W=62.5$, $n_1=7$, $n_2=8$, $p=0.88$; Formulated sentences z-score: $W=53$, $n_1=7$, $n_2=8$, $p=1.0$; Formulated Sentences raw score: $t(13)=1.25$, $p=0.24$, $d=0.64$; BPVS z-score: $t(13)=1.94$, $p=0.08$, $d=1.00$; BPVS raw score: $t(13)=1.16$, $p=0.27$, $d=0.60$; TROG z-score: $t(13)=0.87$, $p=0.20$, $d=0.90$; TROG raw score: $W=49$, $n_1=7$, $n_2=8$, $p=0.44$). The lack of significant differences could be due to the small numbers in each group as a power calculation reveals only a 26% chance of detecting a real difference of 1 standard deviation. Indeed the effect size of 1 standard deviation for the BPVS z-score is not detected. Therefore this study needs to be replicated with larger numbers of children.

Figure 6.3 displays the results for both the SLI groups on the non-standardised tests. As a comparison for the SLI-high group, the figure also shows the scores for their individually matched age controls. Comparisons of the two SLI groups reveal the SLI-high group are significantly better at verb agreement ($t(13)=6.6$, $p<0.001$, $d=3.40$) and tense ($t(13)=3.3$, $p=0.006$, $d=1.71$) but not argument structure ($t(13)=0.10$, $p=0.92$, $d=0.05$).

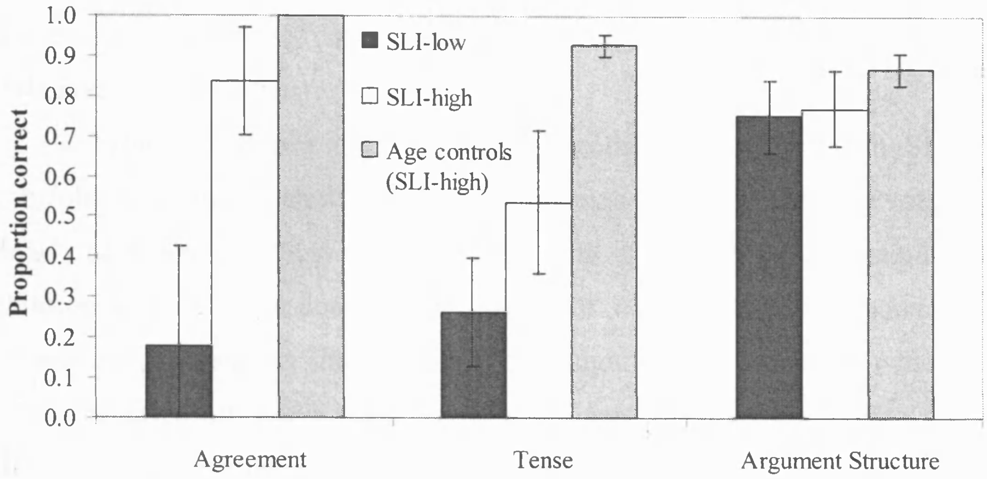


Figure 6.3: Scores on non-standardised tests

As these tests are not standardised, it is important to establish whether the children with SLI are in fact impaired on these measures and whether this impairment is greater than would be expected given their general language levels. Therefore their performance on these measures was compared with that of their individual age and language matched controls. The SLI-high group differed significantly from their age-matched controls on verb agreement ($W=35$, $n_1=7$, $n_2=7$, $p=0.02$), tense ($W=28$, $n_1=7$, $n_2=7$, $p=0.001$) and argument structure ($t(14)=-2.34$, $p=0.04$, $d=1.17$), however they did not differ from either their BPVS or TROG matched controls on tense or agreement ($p>0.14$) and only from their BPVS controls on argument structure ($t(14)=-2.68$, $p=0.02$, $d=1.33$). The SLI-low group scored lower than their *language-matched controls* on verb tense[9] and agreement[10] showing they are particularly impaired in this area. For argument structure however, they did not differ significantly from their language controls, but still scored lower than their age controls ($t(12)=-2.59$, $p=0.02$, $d=1.38$).

6.4.2 Relationship of TOPhS to other language measures

In order to investigate the relationship between performance on the TOPhS and other language measures in both typical development and in SLI, separate correlations were performed for the controls and children with SLI. Pearson and partial correlations (controlling for age) were calculated to examine the relationship between the TOPhS

[9] Tense: an ANOVA showed a significant effect of group ($F(2,16)=20.43$, $p<0.001$, $\eta^2=0.72$). Post-hoc Bonferroni corrected t-tests showed that this was due to a significant difference between the SLI group and both control groups ($p<0.001$, $d>3.1$) with no difference between the control groups ($p=1.0$, $d=0.18$).

[10] Agreement: a Kruskal-Wallis test showed a significant effect of group ($\chi^2(2)=13.8$, $p<0.001$) and post-hoc Wilcoxon signed ranks tests showed a difference between the SLI-low group and both their TROG ($W=28$, $n_1=7$, $n_2=7$, $p=0.001$) and BPVS controls ($W=28$, $n_1=6$, $n_2=7$, $p=0.001$) with no difference between the two control groups ($W=36$, $n_1=6$, $n_2=7$, $p=0.50$).

and raw scores on all available language measures. Correlations were also performed on the z-score of the BAS (raw scores are meaningless as children of different ages are tested on different items).

Table 6.3 shows the correlations for the 15 children with SLI and the 45 controls. The controls show a significant correlation of TOPhS score with age and once this is partialled out, only the correlation with the BPVS remains significant. For the children with SLI, age does not correlate with TOPhS score, but scores on the VATT (Tense and Agreement) show very high and significant correlations which change little when the effect of age is removed. A significant correlation was also found with the BPVS, reinforcing the view that the small group sizes led to insufficient power when comparing the groups with t-tests. However, the difference between the correlations on the VATT and the BPVS was significant (z=2.56, p=0.01).

Table 6.3: Pearson r and partial correlation coefficients (partialling out age) of TOPhS score with other measures.

	Pearson r		**Partial correlations**	
	SLI	Controls	SLI	Controls
Age	-0.03	**0.31***	-	-
BAS (z-score)	0.07	0.04	0.07	0.12
VATT (Tense + Agreement)	**0.94*****	**0.36***	**0.94*****	0.21
BPVS	**0.46***	**0.42****	**0.60***	**0.32***
Argument Structure	0.25	**0.35****	0.27	0.23
Formulated Sentences	0.43	**0.31***	0.43	0.20
TROG	0.26	**0.30***	0.30	0.13

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

6.4.3 The influence of length and phonological complexity

This section considers the factors which influence the performance on the TOPhS of the three groups: SLI-high (8), SLI-low (7) and controls (45). It does not compare their overall performance, as previous sections have already investigated this, but considers only the relationship between their performance and factors underlying the non-words: length and phonological complexity. All analyses in this section are carried out by-items, where the dependent variable is the proportion of children in each group correctly repeating each non-word.

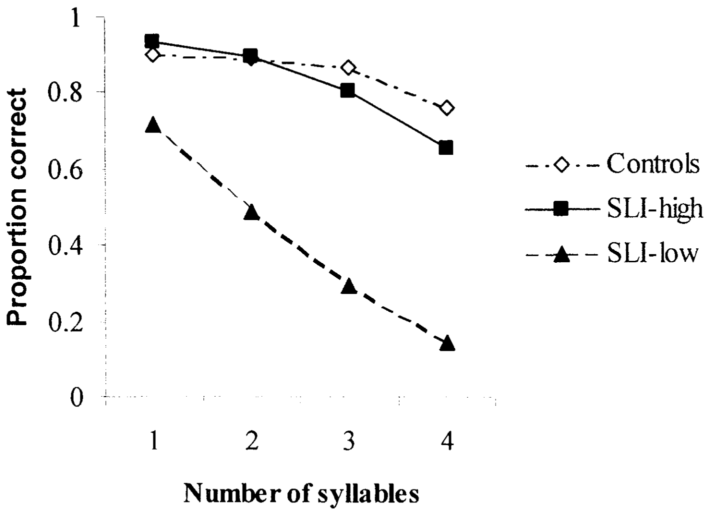


Figure 6.4: The influence of length (number of syllables)

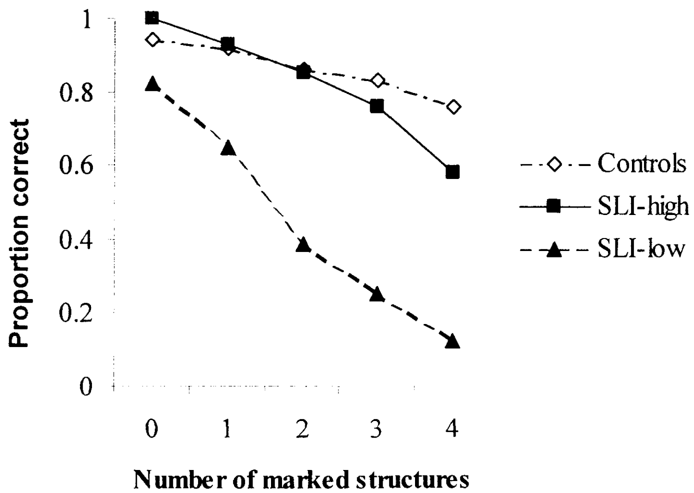


Figure 6.5: The influence of phonological complexity (number of marked structures)

Table 6.4: Spearman rank correlations (r), variance accounted for (r2) and slope (b)

	SLI-low			SLI-high			Controls			Significant differences?	
	r	**r^2**	**b**	**r**	**r^2**	**b**	**r**	**r^2**	**b**	**in r's**	**in b's**
Length	**-0.64******	0.41	**-0.19******	**-0.46******	0.21	**-0.09******	**-0.33******	0.11	**-0.04******	low>cont	low>high>cont
Phonological complexity	**-0.61******	0.37	**-0.18******	**-0.51******	0.26	**-0.10******	**-0.41******	0.17	**-0.05******		low>high>cont
Metrical complexity	**-0.71******	0.50	**-0.29******	**-0.56******	0.31	**-0.15******	**-0.46******	0.21	**-0.08******	low>cont	low>high=cont
Syllablic complexity	-0.14	0.02	-0.05	-0.16	0.03	-0.04	-0.10	0.01	-0.01		
Added consonants	**-0.39******	0.15	**-0.17******	**-0.32******	0.10	**-0.10******	-0.17	0.03	-0.03		low=high>cont
Word End	**+0.28******	0.08	**+0.17******	+0.13	0.02	+0.06	-0.00	0.00	+0.01	low>cont	low>cont, low=high, high=cont

p-values (1-tailed): p<0.05*, p<0.01**, p<0.001***

The graphs in Figures 6.4 and 6.5 show the influence of length (number of syllables) and phonological complexity (number of marked structures) on the performance of the three groups of children. The similarity of the two graphs is striking. Performance appears to be related to both factors, with the SLI-low group generally scoring lower but also affected more by increasing length and complexity than the SLI-high and control groups, as shown by the steeper slopes of the lines. The results were analysed statistically using Spearman (1-tailed) rank correlations (due to the strong ceiling and floor effects); the slope of the lines was also calculated using linear regression for each factor separately. Table 6.4 shows the rank correlations (r), the variance accounted for (r^2) and the slope of the line (b), which indicates the effect on performance caused by a change of one unit in the predictor variable (e.g., one extra syllable or marked structure). Length is measured in the number of syllables and phonological complexity in the number of marked structures. However, as discussed in the introduction to this chapter, phonological complexity can be divided into metrical versus syllabic complexity. Statistics are also shown for these two measures of phonological complexity for each group where metrical complexity is the number of marked metrical structures and syllabic complexity is the number of marked syllable structures. It also shows whether the groups differ in terms of the values of r and b obtained (see Chapter 3, section 3.2.2 for the calculation methods).

The results in Table 6.4 show significant effects of both length and phonological complexity on the performance of all groups of children. However, when phonological complexity is divided into metrical versus syllabic complexity, the relationship with syllable complexity is not significant. This is at odds with other studies which have found effects on performance of syllable complexity as measured by the number of consonant clusters (Bishop et al., 1996; Briscoe et al., 2001). Syllable complexity on the TOPhS consists of three parameters: Onset, Rhyme and Word End. The Onset and Rhyme parameters are more similar to measures of 'phonological complexity' used in the studies listed above, whereas the effect of Word End has not been studied previously. Therefore I also consider the effect of Word End separately from Onset and Rhyme. This reveals that the number of additional consonants added (Onset and Rhyme) is negatively correlated to performance in both SLI groups, whereas Word End shows a positive correlation, whereby the children are *better* at repeating non-words with *marked* Word End, than unmarked Word End (see Table 6.4). Therefore the non-significant correlation of syllable complexity with performance was due to the *positive* correlation of the Word End parameter compared to the *negative* correlation of the

Onset and Rhyme parameters. This tallies with the results in Gallon et al. (2005, ms) which showed that syllable complexity only affected performance on words with two marked metrical structures, none of which have marked Word End.

Comparisons of the correlations and slopes for the three groups for each measure are also shown in Table 6.4. In terms of correlations, the values of r did not differ significantly between the two SLI groups, or the SLI-high group and controls for any of the measures. However, the SLI-low group did have significantly different values of r from the controls on length, metrical complexity and Word End; these factors accounted for more variance in the SLI-low group than in the control group. In terms of the slope of the lines, given by the value of *b* (i.e., the change in performance as a function of the increase in length or complexity), the SLI-low group was more affected by increases in length and complexity than the controls on all measures apart from syllabic complexity. The SLI-high group was more affected than controls by increases in length, overall phonological complexity and number of added consonants (Onset and Rhyme). The SLI-low group was affected more by increases in length and overall phonological complexity than the SLI-high group.

Thus, in summary, the performance of all groups is negatively correlated with both length and metrical complexity and the performance of the SLI groups is also negatively correlated with the number of consonants added to the stressed syllable (Onset and Rhyme). These factors predict performance to the greatest extent in the SLI-low group and least in the control group.

However, because metrical complexity and length are strongly correlated ($r=0.89$, $p<0.001$), it is not clear whether each factor has an independent effect on performance. Therefore, the final analysis considered the independent effects of length, metrical complexity and 'number of additional consonants' (Onset and Rhyme) for each group by carrying out partial correlations for each of these with the proportion of children repeating the non-words correctly, partialling out the effects of the other two factors[11]. These showed that length was not independently related to performance for any group: SLI-low ($r=-0.10$, $p=0.18$), SLI-high ($r=-0.03$, $p=0.40$), Controls ($r=-0.14$, $p=0.09$). Metrical complexity was related to performance for all groups: SLI-low ($r=-0.38$, $p<0.001$), SLI-high ($r=-0.32$, $p<0.001$), Controls ($r=-0.35$, $p<0.001$). However, the number of additional consonants was significantly related to performance only in the

[11] It was not possible to carry out multiple regression because several assumptions necessary for reliable interpretation of the results were violated, including normality in arrays and multiple collinearity

SLI-low ($r=-0.49$, $p<0.001$) and SLI-high groups ($r=-0.36$, $p<0.001$), but not the Controls ($r=-0.14$, $p=0.09$).

6.5 Discussion

This chapter aimed to establish whether all children with SLI have a phonological or short-term memory deficit as measured by a non-word repetition test, whether performance is related to other language abilities and which factors affect performance (length, syllabic or metrical complexity). The results showed that only half of the children with SLI had difficulties repeating the non-words of the TOPhS and performance was strongly related to use of verb tense and agreement and weakly related to receptive vocabulary.

The graphs in Figures 6.4 and 6.5 show a strong relationship between performance and both length and phonological complexity; thus, these data could support both current views of the underlying reasons for difficulty with non-word repetition tasks: phonological short-term memory (Gathercole & Baddeley, 1990) versus difficulties forming phonological representations (Edwards & Lahey, 1998) whether due to auditory (Joanisse & Seidenberg, 1998), mapping (Chiat, 2001) or grammatical phonological difficulties (van der Lely, 2005). However, length and complexity are related, so partial correlations were needed to establish the independent contribution to the variance of each measure and thus to evaluate the above theories. These revealed that the performance of all groups was related to metrical complexity, but only that of the SLI groups was related to syllable complexity as measured by the addition of consonants to form consonant clusters. When the effects of syllable and metrical complexity were removed, length was no longer significantly related to performance in any group. Thus, these results suggest that the TOPhS test and probably also other tests of non-word repetition should be viewed as tests of phonology rather than of short-term memory. Therefore, these findings from the partial correlations do not support the theory that SLI is caused by a limited phonological short-term memory capacity. They do, however still provide support for the theories which claim that difficulties repeating non-words are due to difficulties forming phonological representations. The effect of metrical complexity supports the view that (some, but not all) children with SLI have difficulties identifying the phonological details in rhythmic structure (Chiat, 2001) or difficulties with phonological complexity (van der Lely, 2005). The effect of the addition of consonants to form consonant clusters could support several theories of SLI. Difficulties with clusters could be due a) to auditory processing difficulties, as consonants are difficult to process due to their rapid acoustic changes (Tallal & Stark, 1981; Tallal et al., 1985; Joanisse & Seidenberg, 1998), b) to general processing speed (Bishop, 1994a) or capacity limitations (Leonard, 1998), because the non-words are longer, or c) to a deficit in grammatical phonology, where the children do not have complex phonological templates to aid their formation of representations involving complex structures such as complex Onsets and Rhymes (Marshall, Harris & van der Lely, 2003; van der Lely, 2005).

The claim that the underlying difficulty is with auditory processing is undermined by the finding that the ability to repeat the non-words of the TOPhS is unrelated to performance on auditory tests (van der Lely et al., 2004). As discussed in Chapter 1 (section 1.10.3), it is difficult to distinguish between theories proposing limitations in general processing speed or capacity (e.g., Bishop, 1994a; Leonard, 1998) and those claiming the deficit is directly related to the linguistic system itself (van der Lely, 2005). All of these theories predict that more linguistically complex items will be more difficult. It is not easy to determine whether the child has normal linguistic abilities but limited speed or processing capacities or whether core linguistic difficulties demand more processing resources than other children. However, if processing capacity or speed limitations cause poor performance on the TOPhS this should also adversely affect performance on other language measures such as the TROG and the Argument structure test; this was not the case. A phonological deficit can better account for the fact that the SLI-low group achieve lower scores on the TOPhS but not the TROG or Argument structure test compared to the SLI-high group.

Two questions regarding the relationship between non-word repetition and other language skills in the SLI groups are of interest:

a) Do normal non-word repetition abilities predict normal abilities in other areas of language?
b) Does a deficit in non-word repetition co-occur with deficits in other areas of language and if so, is there a causal relationship?

The answer to the first question is negative: all the children with SLI in this study have significantly impaired language abilities as measured by standardised language tests and also performed below their age-matched controls on the non-standardised language tests, yet only half of them have difficulties repeating the non-words of the TOPhS. Thus, normal non-word repetition abilities do not necessarily predict normal abilities in all areas of language. This calls into question the use of non-word repetition as a clinical marker of SLI (at least with children of this age) as it would lead to many false negatives. Other studies also refer to children with SLI who score within the normal range for their age despite having difficulties in other areas of language (e.g., Botting & Conti-Ramsden, 2001; Edwards & Lahey, 1998) and some report an overlap in scores of some of the children with SLI with controls (Montgomery, 1995a; Bishop et al., 1996; Edwards & Lahey, 1998), but do not report finding a bimodal distribution among their children with SLI as found here.

Despite the dramatic difference in the performance of the two SLI groups on the TOPhS, they did not differ on many of the language measures (CELF-3, TROG, Argument structure or Formulated Sentences). Correlations confirmed the lack of a relationship between non-word repetition and these measures in both the SLI and control groups. This implies that those factors which underlie poor performance on these language measures do not decrease performance on the TOPhS, as the SLI-high group score below age controls on the language tests but not on the TOPhS. The reverse pattern is also indicated: the factor underlying poor performance on the TOPhS (hypothesised to be phonology) does not have an additional detrimental effect on performance in these other language areas, as the SLI-low group do not score worse than the SLI-high group on tests of argument structure, sentence comprehension or formulation, despite their significantly lower scores on the TOPhS.

In contrast to the lack of a relationship between the TOPhS and some language measures, the correlations for both the controls and the SLI groups indicate a relationship between performance on the BPVS and the TOPhS. Such a relationship has been found in other studies with normally developing children (Gathercole & Baddeley, 1989; Gathercole, 1995a; Adams & Gathercole, 1995; 2000; Briscoe et al., 2001) but not in children with SLI (Edwards & Lahey, 1998; Botting & Conti-Ramsden, 2001; Botting et al., 2001; Briscoe et al., 2001; Gallon et al., 2005, ms). Any relationship could be because the proposed difficulty with the formation of phonological representations would impair the children's ability to recognise and learn the phonological representations for new lexical items, thus restricting their vocabulary development. Also, children with larger vocabularies could perform better on non-word repetition tasks because they can use their vocabulary to support repetition of non-words. Indeed, several studies have found children are better at repeating non-words which are more word-like (Gathercole et al., 1991; Gathercole, Frankish, Pickering & Peaker, 1999; Snowling, Chiat & Hulme, 1991; Dollaghan, Biber & Campbell, 1993; 1995; Gathercole, 1995b). These authors propose that a phonological representation of an unfamiliar sequence can be supported either by an abstract phonological reference frame generated from structurally similar vocabulary items or by specific lexical analogy. Alternatively the link could be more indirect (Metsala, 1999; Bowey, 2001); a larger vocabulary store may encourage more segmentalised phonological representations for known words and thus more detailed phonological templates. This would give the child more flexibility in arranging individual phonemes in new patterns and therefore better temporary representations for non-words in non-word repetition tasks.

However, this relationship is not straightforward because the SLI-low group perform much worse on the TOPhS than the control children who are individually matched to them on raw score of the BPVS. In addition, as a group the SLI-high children perform worse on the BPVS than their age controls, even though they do not differ in TOPhS scores. Therefore, for the SLI-high group some factor must impact upon their vocabulary knowledge which does not affect the TOPhS. Both tasks involve the formation of phonological representations, but for vocabulary learning, these representations also need to be stored with a semantic representation. It could be that the SLI-high group perform worse than their age controls on the BPVS, not because they have difficulties forming phonological representations, but because they have difficulties identifying the meanings of the words and associating these with the relevant phonological representation in long-term memory. For the SLI-low group, who perform much worse on the TOPhS than their BPVS controls, their particularly poor performance on the TOPhS must be caused by a factor which affects their ability to repeat non-words more than their ability to match known words to pictures. Difficulties forming phonological representations could affect both these areas; however, this would have a much stronger effect on non-word repetition than receptive vocabulary as more precise phonological representations are needed to produce a word than to recognise it.

Within the SLI group, the relationship between performance on the TOPhS and the VATT is much stronger than with the BPVS. The correlation is almost perfect and the two groups show a highly significant difference in performance on both tense and agreement. A similar finding was reported in Botting and Conti-Ramsden's (2001) comparison of children with SLI who gained high versus low scores on a non-word repetition task. Combining their results with the current study lends weight to the hypothesis that performance on non-word repetition, tense and agreement tasks is affected by a common factor. Indeed, a recent study has shown that inflectional morphology shows high genetic correlations with non-word repetition (Hayiou Thomas, Kovas, Harlaar, Bishop, Dale & Plomin, 2004). In this study, the number of clusters in a word affected non-word repetition; this would also affect tense and agreement as these often involve the creation of word final clusters (Chiat, 2001; Marshall, 2004). However, a phonological difficulty cannot account for the profile of scores of the SLI-high group who scored lower than age-matched controls on the VATT but not on the TOPhS. This indicates an additional factor affects performance on the VATT. This could be difficulty hypothesising the grammatical functions of morphemes with low phonetic salience (Leonard et al., 1992a; Leonard, 1998), knowing that tense and agreement are obligatory in matrix clauses (Rice et al., 1995), or establishing agreement (Clahsen, 1989) or non-local dependencies (movement, van der Lely, 1998).

6.6 Conclusions

The main finding of this chapter is that the children with SLI fell into two groups where their non-word repetition abilities are concerned. They all have significant language difficulties but only half had difficulties repeating the non-words of the TOPhS. Thus, non-word repetition cannot be used as a clinical marker for SLI in isolation (at least in this age group), as it will lead to false negatives. However, it may prove useful in identifying children with particular profiles of difficulties and possibly even subgroups.

The number of participants in this study is small, but if the findings can be replicated, they raise important questions for theories of SLI discussed in Chapter 1. Auditory or phonological processing accounts would predict that performance on a non-word repetition task should correlate with other language tasks and therefore they cannot account for the language difficulties of the group who were able to repeat the non-words of the TOPhS at the same levels as their peers. Most linguistic accounts would claim that this group have purely linguistic deficits and their difficulties with vocabulary and argument structure could be an indirect result of this due to the interrelations between different areas of language, especially in development. However, most linguistic theories cannot account for the differences between the two SLI groups on the TOPhS and the effect this appears to have on their vocabulary and ability to mark tense and agreement. The exception is the CGC (Marshall, 2004; van der Lely, 2005) which claims that deficits in grammatical phonology are functionally dissociable from other areas of language.

Although theories proposing a single underlying deficit for SLI may be more parsimonious, those currently available cannot account for the data in this study. Processing and linguistic theories account for different parts of the data and by combining the two types of theories, an explanation may be found for all the results. I therefore propose that all children with SLI in this study have a linguistic difficulty which affects their performance on a wide range of language tests (e.g., TROG, VATT, CELF-3 and Argument Structure). However, half of the children have an additional (phonological) deficit which causes poor performance on the TOPhS and has a further detrimental effect on vocabulary, tense and agreement. A model which draws together these hypotheses will be presented in Chapter 7.

As far as argument structure is concerned, it seems that it is unrelated to either phonology or phonological short-term memory as measured by the TOPhS non-word repetition test. This provides evidence against those theories of SLI which explain difficulties with argument structure in terms of limited working memory (Leonard, 1998), slow processing speed (Bishop, 1994a) or phonology (Chiat, 2001) and thus predict a relationship between argument structure and non-word repetition. Thus, intervention for argument structure will need to focus on syntax and/or verb semantics and not on phonology. This will be the focus of Chapter 9.

CHAPTER 7 SUMMARY AND DISCUSSION OF PART 1 RESULTS FOR CHILDREN WITH SLI

7.1 Summary and proposed model[12]

The children with SLI studied in Part 1 of this thesis were selected to have severe difficulties with receptive and expressive language (on the CELF-3, a general measure of language), but normal Performance IQ (Matrices and Pattern Construction subtests of the BAS-II). As a group, their standard scores on the BPVS and TROG showed that they were impaired on these measures. Compared to age controls, the children with SLI as a group scored significantly lower in all areas of language: comprehension of vocabulary (BPVS) and sentences (TROG) and formulation of sentences (see Chapter 3), argument structure (see Chapter 5), tense and agreement (see Chapter 6). They also performed worse on the test of argument structure than their BPVS controls (see Chapter 5) and made more errors on the Formulated Sentences subtest of the CELF-3 than all control groups (see Chapter 3). As a group, they achieved significantly lower scores on the TOPhS than all control groups, but this disguised a bi-modal distribution where half the children with SLI did not differ from either language or age controls while the other half scored significantly below all control groups. These two groups of children with SLI did not differ on any of the language measures except their ability to use tense and agreement (the VATT). The group who scored well on the TOPhS achieved similar scores to their language controls on the VATT but still scored lower than their age controls, whereas the group with low TOPhS scores scored significantly lower than both language and age controls.

In order to account for these data, I propose a model where all the children with SLI have an impairment which affects all the language measures listed above (except the TOPhS) and half the children have an additional impairment which affects their abilities to repeat the non-words of the TOPhS, i.e., half the children have a double deficit. While most theories of SLI propose a single deficit, several researchers have recently proposed that dissociable deficits or risk factors may better account for the data. Bishop et al. (1999b) proposed that a series of risk factors may be involved in SLI and those children with more than one risk factor are likely to show a more severe

[12] A previous version of this model was presented at the Boston University Conference on Language Development, October 2003.

deficit. Bishop and Snowling (2004) proposed that children with classic dyslexia have a poor phonological skills, poor reading comprehenders have poor semantic skills, but children with SLI have both phonological and semantic difficulties. Marshall (2004) and van der Lely (2004; 2005) propose the Computational Grammatical Complexity Hypothesis (CGC) whereby children with SLI may have independent but interactive deficits in any one or a combination of phonology, morphology and/or syntax. They propose that deficits in each of these areas are related to grammatical complexity in that area.

I will now consider the possible nature of the deficits which would best account for the data presented in Part 1 of this thesis. In Chapter 6, I showed that the factors which most affected the children's scores on the TOPhS test were metrical complexity and the number of additional consonants; word length had no independent effect. Thus, I concluded (as do Gallon et al., 2005, ms) that performance on the TOPhS is best accounted for by phonological rather than short-term memory abilities. Those children who have difficulties with the TOPhS thus appear to have a phonological deficit which is affected by complexity in terms of marked metrical structures and consonant clusters. This is in line with the proposals of the CGC. The relationship between scores on the TOPhS and the ability to use tense and agreement is likely to be due to the consonant clusters which are frequently formed by the addition of word final /t/, /d/, /s/ or /z/ for tense and agreement marking which children with phonological difficulties find hard (Chiat, 2001; Marshall, 2004).

The hypothesised phonological deficit does not appear to be related to the other areas of language, as shown by the lack of difference between the two groups of children with SLI on language measures such as the TROG, CELF-3 and argument structure. Therefore, some other factor must be involved in the children's difficulties with constructing and understanding sentences, which does not affect their ability to repeat non-words. The processing theories of SLI (introduced in section 1.10 in Chapter 1) would all predict difficulties with non-word repetition in addition to other language measures and therefore only account for half the children with SLI in this study. Most linguistic theories of SLI claim that the ability to repeat non-words is unrelated to other language areas and thus these theories may be able to account for the impaired language scores in all the children. Some theories focus only on morphology and can thus only account for the difficulties with tense and agreement, but not with vocabulary, forming and understanding sentences and argument structure; these include the Feature Blindness / Rule Deficit (Gopnik, 1990b; Gopnik & Crago, 1991; Gopnik & Goad, 1997), Agreement Deficit (Clahsen, 1989; Clahsen et al., 1997) and the Extended Optional Infinitive (Rice et al., 1995) hypotheses. In contrast, the Representational Deficit for Dependent Relations hypothesis (van der Lely & Stollwerck, 1997; van der Lely, 1998; van der Lely & Battell, 2003), is broader and accounts for the difficulties with understanding sentences and using tense and agreement. Difficulties with syntactic bootstrapping or reverse linking (van der Lely, 1994) could also lead to imprecise semantic representations for verbs and thus argument structure errors (see Chapters 2 and 5). Therefore it is possible that a syntactic deficit (such as that proposed in the RDDR) could underlie the difficulties with several areas of language, but would not affect the children's abilities to repeat non-words.

Therefore I propose the model shown in Figure 7.1. In this model I show that all the children with SLI in this study have a syntactic deficit which affects morphology and syntax; this in turn affects the ability to use syntactic bootstrapping and hence learn argument structure and to a lesser extent vocabulary. In addition, I propose that half of the children also have a phonological deficit which affects their ability to form phonological representations, especially those with complex metrical structures or consonant clusters. This in turn affects their ability to repeat phonologically complex non-words and also further impairs their ability to use verb tense and agreement.

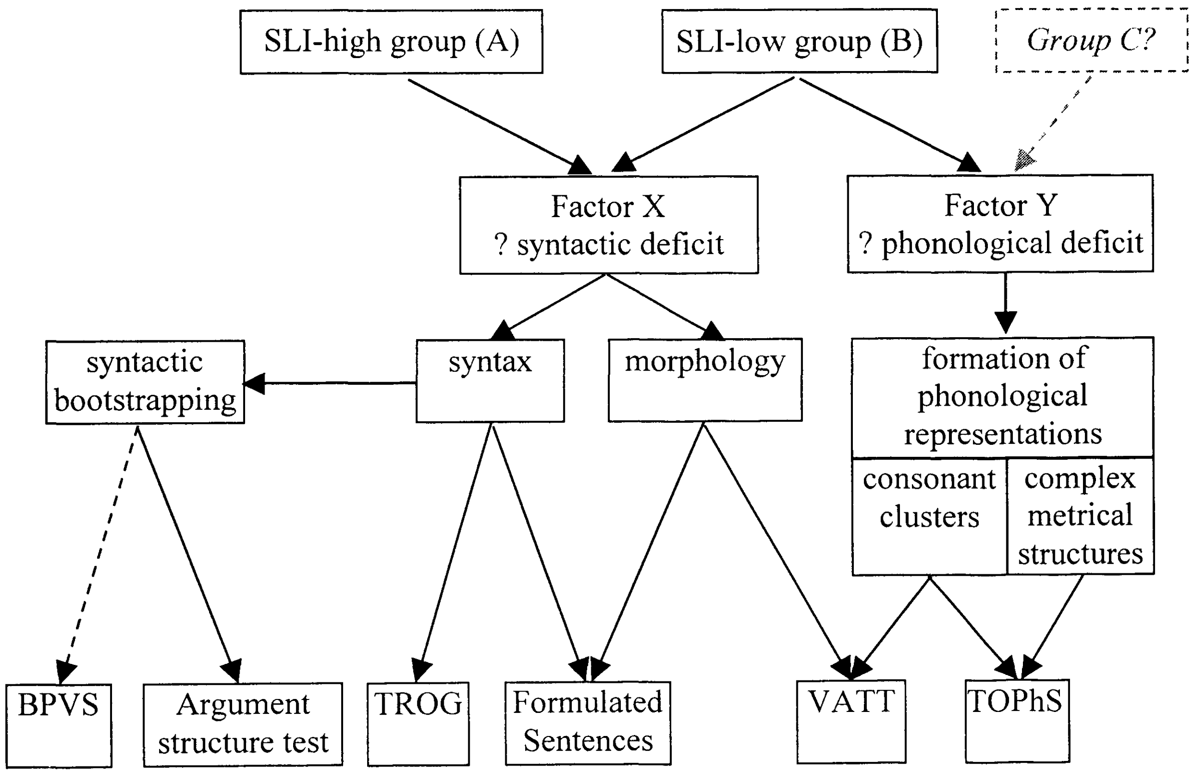


Figure 7.1: Model of proposed deficits

7.2 Implications for studies and theories of SLI

The model in Figure 7.1 raises the possibility of another group of children who have a single phonological deficit (Group C on the model). These children would not have difficulties with argument structure or understanding sentences but would still make tense and agreement errors. Such children would not have been included in this study because the criteria for the SLI participants specified difficulties with both receptive language and expressive language. However, the literature contains many studies of children with SLI with no receptive difficulties who may have the proposed phonological deficit without a co-occurring syntactic deficit. This model and the CGC (which this model fits well within) therefore make clear why tense and agreement difficulties are the most frequently reported; all children with language impairments, whether due to a syntactic or phonological impairment or both, would have difficulties with verb morphology as it requires both syntactic knowledge (in order to identify when Tense is required, cf. Rice et al., 1995; van der Lely, 1998) as well as good phonological abilities (to produce the word final consonant clusters involved, cf. Chiat, 2001; Marshall, 2004).

This model can also account for the findings (discussed in Chapter 1, section 1.8) that children with moderate sensori-neural hearing losses have equal phonological difficulties to children with SLI but score higher on a range of language measures (Briscoe et al., 2001; Norbury et al., 2001; 2002). The children with hearing losses may have an equivalent phonological deficit to some of the children with SLI, but do not have the syntactic deficit which affects the children with SLI, thus they differ on syntactic but not on phonological measures.

The three groups of children proposed by this model roughly correspond to three of those proposed by Rapin and Allen (1987), (Chapter 1, section 1.3, Figure 1.1): SLI-high group (A) = Lexical syntactic deficit syndrome, SLI-low group (B) = Phonologic-syntactic deficit syndrome, ?Group C = Phonological programming deficit syndrome. However, this model provides more explanation for the patterns of overlapping symptoms seen in Figure 1.1. I propose that two deficits underlie these symptoms: phonological and syntactic and some children have only one of these deficits. This accounts for the lack of overlap between the Phonological programming deficit syndrome and Lexical syntactic deficit syndrome, where the children are hypothesised to have a single underlying deficit. However, some children have a double deficit (Group B - Phonologic-syntactic deficit syndrome) and for this reason, their symptoms include those of both other groups. In section 1.3, I discussed the study by Conti-

Ramsden and Botting (1999) which showed that the Rapin and Allen subgroups are unstable over time. This was mainly due to changes in vocabulary and output phonology. However, only output phonology was considered, whereas the TOPhS is hypothesised to tap underlying difficulties with phonological complexity. The majority of the children in the SLI-low group in this thesis had no current difficulties with output phonology, although several had had difficulties in the past. Thus, it seems that while children's difficulties with output phonology may improve with age and intervention, the underlying phonological difficulty as measured by the TOPhS may remain. Indeed Bishop et al., (1996) found that children whose language difficulties have resolved still showed difficulties repeating non-words.

If a model such as that in Figure 7.1 is borne out by future research, it could provide an explanation for the many competing theories of SLI. Depending on the criteria used to identify the children, studies may include children with either a syntactic or phonological deficit or both. Thus, the finding that children "with SLI" have difficulties with verb morphology will be the strongest and hence the most studied effect (see Chapter 1). The strength of the findings of group studies of syntax or phonology (including non-word repetition) will vary according to the proportion of children in the SLI group who have phonological or syntactic deficits. Therefore studies (such as those by van der Lely and colleagues) which include syntactic criteria in their selection of SLI participants, are likely to find stronger effects of syntax when comparing the children with (G-)SLI to normally developing peers (van der Lely, 1994; van der Lely & Stollwerck, 1997; van der Lely, Rosen & McClelland, 1998; van der Lely & Battell, 2003) compared to studies which do not include syntactic criteria. Conversely, because phonological criteria are not used, the G-SLI children may or may not have a phonological deficit and thus any findings with regard to phonology (including non-word repetition) are likely to be weaker (van der Lely & Howard, 1993). When considering theories of SLI, it is thus important to consider carefully the inclusion/exclusion criteria applied in the studies on which the theories are based. Van der Lely's RDDR hypothesis for example, is based on studies of children selected to have morpho-syntactic difficulties and aims to account for these difficulties only. Other studies (including those in this thesis) use more general participant selection criteria and it is therefore vital that they provide information about the individual variation within the SLI group. Where such data are examined in detail (as in Chapter 6) it is possible to answer broader questions about the nature of SLI and the relations between possible subgroups. However, where such data are not provided or analysed, it is difficult to know if the group effects reported are representative of all the children with SLI in the study or whether the results have been diluted by the inclusion of children with different profiles of difficulties. Thus any difficulties which apply to only some of the children "with SLI" may either be missed, or attributed to the whole group. Either way, theories based on such studies need to be interpreted with caution.

7.3 Implications for intervention

Intervention will need to vary according to the type of deficit(s) the child is hypothesised to have as well as the area of language which is being targeted. According to the model in Figure 7.1, any child who has difficulties with language measures in addition to tense and agreement is hypothesised to have a syntactic deficit while children who have difficulties with vocabulary, tense and agreement may have a phonological deficit and/or a syntactic deficit. A non-word repetition test such as the TOPhS seems a good way to diagnose a phonological deficit, as the children who found this difficult obtained scores which were well below all the controls and all those with SLI who had no such difficulties. Any intervention needs to identify those areas where the child has difficulties and hypothesise the possible underlying reasons for this. An intervention program can then be designed to work on the target language area either by focusing directly on the area of hypothesised difficulty or using alternative strategies to enable the child to improve their performance in these areas. The decision regarding the actual method of intervention depends partly on the hypothesised difficulties, the area of language targeted and also on the results of past research which should indicate which methods work best, for which targets and which children. Chapter 8 therefore presents a review of intervention studies for children with SLI in order to establish our current knowledge in this area and identify areas for further research.

One aim of Chapter 6 was to evaluate whether difficulties with argument structure were related to phonology or short-term memory as measured by a non-word repetition task. This was not the case; therefore intervention for argument structure need not include a focus on phonology or short-term memory. Chapter 5 showed argument structure difficulties were most closely related to syntactic difficulties and the priority areas for intervention with SLI are change of state verbs and omission of obligatory arguments. I hypothesised that children with SLI make errors with change of state verbs due to underspecified semantic representations as a result of difficulties using syntactic bootstrapping; this could be due to their hypothesised syntactic deficit (see Figure 7.1). Application of forward linking to these representations leads to use of the incorrect construction. Two possible methods of intervention therefore present themselves: 1) provide the children with additional information regarding the semantic representations of the verbs, in particular the change of state of the Patient, so that their semantic representations become more accurate despite difficulties using syntactic bootstrapping; 2) focus the child's attention on the construction used with these verbs and explicitly teach them the relationship between thematic cores and constructions. In 1), the child's semantic representations should change for the targeted verbs leading to use of the correct construction. However, improvement is not predicted to generalise to other change of state verbs. In 2), the children should learn the constructions associated with targeted verbs but they may also begin to improve their use of syntactic bootstrapping due to an increased awareness of the links between constructions and thematic cores; this should lead to generalisation to untreated change of state verbs.

For obligatory arguments, I hypothesise that errors could occur due to the children's difficulties in marking arguments as obligatory. This could result from a syntactic deficit, as they may not note the syntactic constructions in which verbs occur. Intervention could focus the children's attention on the constructions used with verbs by providing visual templates for different constructions. This may improve their ability to note constructions and thus mark arguments as obligatory for a range of verbs. However, the child's learning may be restricted to associating particular constructions with particular verbs; this would lead to fewer omissions of obligatory arguments for taught verbs, but generalisation would not be expected. Intervention which focuses purely on verb semantics is not predicted to increase the use of obligatory arguments.

Hence, Chapter 9 will focus on two types of intervention for argument structure. The first is primarily semantic (increasing the children's awareness of the fine semantic details in verbs' semantic representations) and the second uses a visual coding system designed to increase their awareness of the links between constructions and thematic cores and also of obligatory versus optional arguments. Both therapy methods are predicted to improve the use of the correct construction with change of state verbs, but generalisation to untreated verbs is not predicted for the semantic therapy. Only the second therapy method is predicted to increase the use of obligatory arguments. These two therapy methods are described in detail in Chapter 9.

Part 2 of this thesis will therefore consist of an intervention study for argument structure (Chapter 9), preceded by a review of the literature regarding the evidence for intervention in general for children with SLI (Chapter 8). Chapter 10 will summarise the findings of the whole thesis and discuss their implications for both theory and therapy.

PART 2

ARGUMENT STRUCTURE IN SPECIFIC LANGUAGE IMPAIRMENT:

THERAPY

CHAPTER 8 INTERVENTION FOR CHILDREN WITH SLI

8.1 Introduction

Intervention studies for children with SLI are of great practical and theoretical importance as they can inform both clinical practice and theories of SLI. However, the language intervention research base is extremely limited, particularly for school-aged children and children with receptive language difficulties (Law, 1997; Law, Boyle, Harris, Harkness & Nye, 1998; Law, Garrett & Nye, 2004; McCartney, Boyle, Bannatyne, Jessiman, Campbell, Kelsey, Smith & O'Hare, 2004). This is a serious problem for clinical practice as it is precisely these children who are likely to have the most persistent language and consequently educational and social difficulties and hence heavier resource implications (Bishop & Edmundson, 1987; Silva, Williams & McGee, 1987; Law, 1997; Howlin et al., 2000; Mawhood et al., 2000; Tomblin, Zhang, Buckwalter & O'Brien, 2003; Clegg et al., 2005). In addition, very few intervention studies have any theoretical basis. This is unfortunate for clinical practice as interventions based on a sound theoretical understanding of the nature of the linguistic targets and the children's difficulties are more likely to be effective. This lack of intervention studies grounded in a theoretical framework is also a missed opportunity for evaluating theories of SLI, as current theories have different implications for intervention (see Chapter 1, section 1.11) and the success or failure of an intervention based on a particular theory can provide evidence for or against that theory. It is therefore highly desirable that much closer links are formed between those undertaking theoretical and intervention research as this would lead to greater understanding of the difficulties children with SLI experience and the best routes to remediation.

The ultimate aim of intervention research is to establish which methods work best, for which language targets and for which children. The majority of intervention studies have focused only on the method of intervention with very little consideration for the particular areas of language targeted or the characteristics of the children. Because of this, the studies in this chapter are grouped by their method of intervention. Where the information is available, the target of the intervention and ages of the children will be described with each study. This chapter will only focus on studies which aim to improve the areas which are related to argument structure, the focus of

Chapter 9 (i.e., production and comprehension of grammar and vocabulary but not phonology, articulation or pragmatics).

Given the focus of the theoretical studies in Chapter 1, it is unsurprising that the majority of intervention studies focus on expressive language, particularly morphology. Studies aimed at improving comprehension are rare as are those focusing specifically on the production or comprehension of syntax or argument structure. The focus of this chapter is only on intervention studies for children with SLI and will therefore include only studies of children with language impairments in the absence of other difficulties who are over the age of 4 years, as SLI is difficult to diagnose before this age. Indeed, in one study, only 56% of children diagnosed at age 4 showed continuing difficulties by 5;6 years (Bishop & Edmundson, 1987) while of those diagnosed at 5 years, 81% continued to have problems at 12 years (Beitchman, Brownlie, Inglis, Wild, Mathews, Schachter, Kroll, Martin, Ferguson & Lancee, 1994). Thus, studies with children under 4 years of age may include a substantial proportion of children who show only a language delay and not SLI.

In Chapter 1 (section 1.11), I discussed the implications of theories of SLI for intervention methods and proposed that for intervention to have the most chance of being effective it needs either to work directly on the underlying deficit or to provide alternative routes to learning language.

The intervention approaches which have been the focus of the most research (those discussed in section 8.3) are not based directly on any of the theories of SLI described in Chapter 1. These are based on models of normal language acquisition and aim to make target forms more frequent thus helping the child identify grammatical rules and also to give the child practice at producing forms they tend to omit. The claim is that this should lead "most directly to the ultimate destination: competent use of grammar in oral and written modalities and in comprehension as well as production" (Fey & Proctor-Williams, 2000, p179). However, this rests on the hypothesis that children with SLI have normal language learning mechanisms and can infer grammatical rules from their linguistic environment when presented with 'sufficient' evidence. This implies that children with SLI merely require more input than typically developing children in order to infer the rules of grammar, but no theoretical explanation is given as to why this may be.

The studies discussed in section 8.4 and 8.5 in contrast to those in section 8.3 are based on particular theories of SLI (although this is not usually made explicit). Those in section 8.4 aim to improve a hypothesised underlying temporal processing deficit by training the auditory system using acoustically modified speech. The general language abilities of the children are then hypothesised to improve as a direct consequence of the children's improved temporal processing. Conversely, the studies in section 8.5 do not aim to improve the underlying deficit but to provide alternative routes to learning language through the use of metalinguistic methods often supported by a visual coding system. These methods implicitly assume that the children cannot learn language in the typical way due to an intractable deficit (possibly a linguistic or auditory deficit).

8.2 Evaluation of intervention methods

In many ways, intervention research for children with language difficulties has proceeded in a relatively ad-hoc manner. Several authors have highlighted the distinction between *efficacy* and *effectiveness* research and suggest that a more systematic research program would result from increased use of this distinction (Law, 1997; Robey & Schultz, 1998; Cleave, 2001; Pring, 2004). *Efficacy* research involves an evaluation of the benefits of treatment under ideal, rigorously controlled 'laboratory conditions', i.e., optimally selected and trained clinicians and patients, optimally delivered treatment, structured conditions for delivering treatment, and optimal measures or indices of change. Once a treatment has been shown to be efficacious under these conditions, its '*effectiveness*' under typical clinical conditions (in the 'real world') can be investigated. Robey and Schulz (1998) and Pring (2004) in particular are very clear that effectiveness studies should only be conducted after the efficacy of a treatment has been established. Two main reasons for this are: 1) where current practice is based on sound research, there is no justification for trying a new treatment in routine clinical practice until there is some indication of its efficacy under ideal conditions; 2) a null result in an effectiveness study needs to be evaluated in the light of the preceding efficacy studies in order to draw conclusions regarding whether the null result is due to the nature of the treatment or the nature of routine clinical conditions. In the speech and language therapy profession, current practice in many areas is based only on clinical experience and not on sound research; therefore the first reason is less relevant. However, the second reason is still applicable and several recent studies of therapy delivery in the UK with null results are un-interpretable for this reason (Pring, 2004).

Robey and Schulz (1998) describe a 5-phase model for clinical outcome research, which they have adapted for aphasiology and could be used for work with SLI (hereafter called the R+S model). This model will be used throughout this chapter to aid evaluation of the current research base in SLI. The 5 phases are described below:

Phase 1: detect a therapeutic effect using small-scale group experiments and single case studies. In this chapter, I will assume that studies without experimental control are at Phase 1.

Phase 2: Use further small studies to develop the basic treatment protocol, select outcome measures and identify ideal participant characteristics. I will assume that for studies to be considered as Phase 2 evidence, they have to include experimental control.

Phase 3: Carry out efficacy testing using relatively large-sample, parallel group experiments with control participants, preferably in randomised control trials (RCTs). In the confirmatory stages, the critical test of treatment efficacy is to compare the efficacy of a new treatment with that of traditional treatments which are already known to be efficacious.

Phase 4a: Continue efficacy experiments with 3 possible foci: a) subpopulations of one population or b) different populations and c) possible variation in treatment protocol. Start to synthesize outcomes of Phase 3 studies through meta-analysis.

Phase 4b: Carry out large-scale effectiveness studies that evaluate treatment as used under typical circumstances. Assess the therapeutic effects attributable to different forms of service delivery, level of clinician training or variations in population definition. Such studies require parallel-group experiments or smaller scale, highly structured and rigorously controlled single-subject experiments with multiple replications.

Phase 5: Continue effectiveness research using large numbers of participants. External controls are not required, as efficacy has been proven at Phases 3 and 4a. Carry out further meta-analyses and assess effectiveness in the context of associated costs, consumer satisfaction and quality of life.

The studies reviewed in the remainder of this chapter will be considered in terms of this model. This allows us to establish to what degree a particular method of intervention has been proven to be efficacious or effective and to suggest areas where further research is required.

8.3 Grammar facilitation methods

Grammar facilitation methods are the mostly widely investigated in intervention research studies. The most common approaches are imitation, modelling or focussed stimulation, expansion and recasting.

8.3.1 Imitation

In imitation approaches, the adult provides a non-verbal stimulus (e.g., a picture) and the target form; the child then imitates it and receives reinforcement for correct productions. The adult model and reinforcements are gradually reduced until the child produces the target in response to the non-verbal stimulus only. The main aim of the imitation method is to increase the frequency of the target forms both in the input and in output, without unrelated forms intervening, thus increasing the chances of the child inferring the grammatical rule. Reinforcement encourages the child to attend to the linguistic forms and is presumed to make the child more likely to produce the form again under similar circumstances. An inherent assumption in this approach is that providing production practice may strengthen the child's underlying linguistic knowledge.

The effects of imitation on the ability to produce longer, more grammatically correct sentences have been investigated over many years. Preliminary research at Phase 1 of the R+S model indicated the possible usefulness of this approach (Gray & Fygetakis, 1968). Studies at Phase 2 showed imitation methods to be effective in single cases for increasing the length of utterances in a 5 year old with SLI (Fygetakis & Ingram, 1973) and for increasing the productions of *she, he, him* and *are* from zero to 100% in a child with SLI aged 4;9 years (Hegde & Gierut, 1979).

A randomised control trial (at Phase 3) showed this type of intervention (using the Monterey language program) was effective at improving both articulation and production of syntax in children with SLI aged 5;5-6;10 (Matheny & Panagos, 1978). Another RCT of this program (with children aged 4;4-6;3) showed it was more effective than articulation therapy for improving the production of yes/no questions in the clinic setting, but generalisation only occurred to the home setting with an additional 'extended transfer program' (Mulac & Tomlinson, 1977). This consisted of additional sessions with the clinician and parent out of the clinic setting and with the parent at home where the target form was elicited in the context of conversation and stories.

Further studies at the confirmatory level of Phase 3 showed that children with SLI (aged 3;10-5;11) learn novel derivational morphemes better with imitation than with modelling (Connell, 1987). However, this effect is restricted to production, as another group (aged 5;0-6;11) were able to comprehend new morphemes to an equal extent with both methods (Connell & Stone, 1992). These authors conclude that the children are able to infer new rules from both methods and their production difficulty could lie with building stable phonological representations of the new morpheme in long-term memory. This could be aided by repeated production of the target in the imitation method. This has obvious implications for theories of SLI but the conclusions should be treated with caution as both studies used derivational morphemes, an area of grammar which has not been identified as causing difficulty in SLI.

8.3.2 Modelling / focussed stimulation

Modelling and focussed stimulation approaches are similar to imitation in that they also assume the child can infer grammatical rules through repeated exposure to examples of the rule. The main difference from imitation is that the child is not required to respond, merely to listen. Modelling approaches direct the child's attention to the stimuli but they do not give any explicit guidance on which particular features to attend to, e.g., "listen to *how* I'm asking questions" (Ellis Weismer & Murray Branch, 1989). Focussed stimulation in contrast does not direct the child's attention to the model in any way. Evoked production in response to a picture or situational stimulus may follow the modelling period. This differs from imitation in that the child does not imitate the precise words used in the model but produces a novel utterance which uses the same rule. Feedback is usually given as to the correctness of the child's production. The degree of modelling is gradually reduced during the intervention programme as the child begins to use the new rule productively.

At Phase 2 of the R+S model, a study of 8 children with SLI (aged 5-9 years), found modelling with evoked production increased the ability of the experimental group to produce 'is' and 'don't' significantly more than a delayed therapy group (Leonard, 1975). Another study showed modelling without evoked production was effective in teaching auxiliary 'is' and auxiliary inversion to three children with expressive SLI (aged 5;5-6;11), but the addition of evoked production led to a more stable learning pattern (Ellis Weismer & Murray Branch, 1989). However, neither method was successful in teaching *'he'* to a fourth child (aged 5;6) with more global SLI affecting phonology, expressive and receptive language. They suggest this could be either because he was less accustomed to intervention procedures or because he had little knowledge of the syntactic properties associated with sentence subjects and hence may not have been ready to focus on individual pronouns.

At Phase 3 of the R+S model, a quasi-experimental group design study involving 24 children with SLI (aged 3;8-8;2) showed modelling with evoked production increased their accuracy in producing *'wh'* questions (Wilcox & Leonard, 1978). The experimental group performed significantly better than controls after therapy; the controls then also received therapy and also made significant progress. Also at Phase 3 (the confirmatory stage), Courtwright and Courtwright carried out two studies comparing the effectiveness of imitation and modelling methods. In the first (Courtwright & Courtwright, 1976), they showed children with SLI (aged 5-10 years) improved their production of *they* in subject position (as opposed to *them*) more with modelling than imitation therapy. In the second (Courtwright & Courtwright, 1979), they randomly assigned 36 children with SLI (aged 3;11-6;11) to 6 experimental groups to compare imitation, clinician-led modelling and third party-led modelling and also to compare the effects of reinforcement within each therapy type. They used an artificial grammatical 'rule' to which none of the children would have been exposed pre-therapy. Their results showed the children produced the new form more reliably if they had been taught using a modelling approach rather than imitation. The use of reinforcement made no difference to the level of change in performance, neither did the use of a third party versus clinician to deliver the models.

8.3.3 Recasting / expansion

Recasting and expansion methods are used during activities involving an adult and child and are designed to be non-intrusive conversational procedures. The adult does not initiate the teaching directly, but manipulates the activity to increase the chances of the child using certain targeted grammatical forms. When the child fails to use the target form or makes an error, the adult immediately follows his utterance with a modified version which includes the target form (a 'recast'). For example, if a child says "teddy fall down", the adult may follow this with "yes, teddy fell down". The theory behind this approach is that the child is likely to be more interested in what the adult is saying if it links semantically with the situation and the child's own prior utterance. The immediate contrast between the two forms also focuses the child's attention on the features of the utterances that differ. In addition, the child does not need to parse the adult's meaning and thus has more processing resources available for analysing the target form in the recast. This method has been shown to be effective at increasing the use of target structures in children with typical language development (Nelson, Camarata, Welsh, Butkovsky & Camarata, 1996; Saxton, 1997; Saxton, Kulcsar, Marshall & Rupra, 1998).

At Phase 3, one study (Fey & Loeb, 2002) investigated the efficacy of recasting at encouraging the use of auxiliaries and modals by children with SLI and younger typically developing children. They found no effect of recasting the children's utterances into yes-no questions with sentence-initial auxiliaries. However, the children in the study did not use any auxiliaries pre-intervention and therefore may have been unable to benefit from the intervention as Saxton (2000) found that negative evidence (in the form of a type of recast) was more effective at increasing the use of target forms when the child already showed 50% use of the forms.

At the confirmatory stage of Phase 3, several studies have compared the effects of conversational recasting and imitation at increasing the production of a range of morpho-syntactic structures in children with SLI (Camarata & Nelson, 1992; Camarata, Nelson & Camarata, 1994; Nelson et al., 1996). These studies all show that targets treated with either type of intervention improve more than those which are not treated, but the children use the target forms *spontaneously* after fewer presentations in the recasting than the imitation condition. The imitation condition in contrast was superior for decreasing the number of presentations required before the first *elicited* production of the target (Camarata et al., 1994). The pattern of learning using these methods was similar in the children with SLI and younger children matched on language ability (Nelson et al., 1996). However, there was some evidence of an interaction of target type, child and intervention method. Camarata & Nelson (1992) found the passive construction was acquired faster using conversational recasting, whereas the gerund was acquired faster with imitation. Individual variation was revealed in Camarata et al. (1994) when three of the 21 participants only acquired their targets with imitation training and three only with conversational recasting.

8.3.4 Modelling plus recasting

Some investigations of intervention with children with SLI use a combination of the grammar facilitation methods discussed above. In particular, modelling with evoked production together with recasting or expansion has been shown to be effective for generalisation of grammatical rules in four SLI children aged 4;6-9;2 (Culatta & Horn, 1982) and also for increasing grammatical accuracy and range in children aged 3;8-5;10 (Fey, Cleave, Long & Hughes, 1993; Fey, Cleave & Long, 1997). The experiments by Fey and colleagues involved a larger group of children (30) who were randomly assigned to groups (hence at Phase 3 of the R+S model) and also investigated the role of parents in the delivery of intervention. Taken together, these studies showed a significant effect of intervention, whether delivered by parent or clinician. This was in stark contrast to the children who received no intervention and made very little progress. The children in the clinician group made more reliable progress than those in the parent group. However, the reason for this is unclear as the interventions differed in content as well as administrator. The primary method in both groups was modelling and recasting, but the children in the clinician group also imitated contrastive drills and participated in group sessions.

One hypothesis investigated in detail is whether parental use of recasts was related to the gains made by the children. In both studies, after intervention, the parents in the parent group on average produced more recasts than the other parents. However, there was considerable variation within the parent group and the authors claimed this was related to child language gains. In the first study, parents who used the least recasts after intervention had children who made the *greatest* gains and hence had the *highest* scores post-therapy (as the groups were matched pre-therapy). In contrast, in the second study, those parents who used the least recasts had children who a) made the *smallest* gains, but b) also had the *highest* scores post-therapy (presumably they started with higher scores too). Thus it seems that parental recasts post-therapy are related to child language scores post-therapy rather than language gains. It could be that the child's language levels predict parental recasts rather than vice versa as the authors suggest. Indeed parental recasts occur in response to child errors and thus high error rates are likely to lead to higher recast rates in parents. Gains are related to post-therapy language scores and hence the hypothesised link between language gain and parental recasts could be mediated by the child's language levels; no direct relationship need be involved. Given this possible explanation for the data, it is premature for the authors to conclude that the studies add to evidence of the "facilitating effects of sentence recasting on the grammatical development of children with language impairments".

However, the gains shown by the children of these parents as compared to the control children need to be explained. If recasting does not directly cause language gains, then some other feature of the parent intervention must be encouraging the children's language to improve. Possible contributing factors could be the increased use of modelling of target forms, or merely the increased time parents may have spent interacting and talking with their child. Thus, while these studies indicate the efficacy of the global therapy package, they do not reveal which features of the intervention are responsible for the improvement in the children's scores.

8.3.5 General approaches

Several studies compare general intervention approaches involving a mixture of specific techniques. However, only one includes children over 4 years of age with performance IQs in the normal range (Friedman & Friedman, 1980). This study compared two broad intervention approaches with children with SLI (aged 3;2-5;9). The first was a conversational approach (but included imitation, focused stimulation, elicitation by questions, reformulating, remodelling, correcting and expanding responses) and the second a more structured approach (involving imitation, modelling, reinforcement and generalisation). No main effect of treatment was found; both groups showed equal and significant gains in Developmental Sentence Score (DSS). However, the lower functioning children benefited more from the structured approach and the higher functioning children more from the interactive approach. This study therefore highlights the need to consider the relationship between the success of intervention methods and the characteristics of the children involved.

8.4 Fast ForWord – acoustically modified speech

The intervention studies led by Tallal and Merzenich (Tallal et al., 1996; 1998; Merzenich et al., 1996) are distinct from those discussed so far in that they focus mainly on processing of sounds and comprehension rather than expressive language and are based directly on a particular theory of SLI: children with SLI have difficulty processing rapid or brief stimuli (Tallal et al., 1985 - see Chapter 1). In the initial studies (Tallal et al., 1996; Merzenich et al., 1996), the children listened to acoustically modified speech where the duration of the speech was prolonged by 50%, and the transitional elements enhanced by up to 20dB. Two studies are presented in the Tallal et al. (1996) paper. The first is a small group study with no controls, therefore falling in Phase 1 of the R+S model. In this study, seven 'language learning impaired' children (mean age: 7 years) carried out speech and language listening exercises and listened to children's stories, both recorded with the acoustically modified speech for four weeks: 3 hours per day, 5 days a week in the laboratory and an additional 1 to 2 hours per day, 7 days a week at home. The authors reported the children's speech discrimination and language comprehension improved significantly, approaching or exceeding normal limits for their age, whereas they initially scored 1-3 years below their chronological age. Unfortunately, all the data are given in age equivalents and not standard scores and the results are therefore difficult to interpret. For example, on the Token Test, the mean age equivalents pre- and post-therapy were approximately 5;6 and 7;6 (a change of two years). While this may seem to be a large change, inspection of the published means and standard deviations for this test shows that the raw scores associated with these age equivalents are both within +/-1SD of the mean for a child aged 7 years. Therefore, although the authors state that the post-therapy scores were within normal limits, pre-therapy scores also appear to be within normal limits. The clinical significance of these findings is therefore questionable.

Tallal et al.'s (1996) second study explicitly investigated the effect of the modified speech by comparing the change in language scores in two groups of 'language learning impaired' children (aged 5-10 years), carrying out the same tasks as in Study 1, but either with or without modified speech. They found that both groups made significant progress, but the group trained with the modified speech made significantly more progress than the other group. They also state that the gains achieved in training were 'substantially maintained' when they were re-tested 6 weeks later (although they provide no evidence for this). This study could be viewed as providing a test of the method at Phase 3 (R+S model). However, although this is a group design it has several shortcomings, particularly the lack of a control group who did not receive any targeted therapy. Hence, the large gains in scores could be due either to a practice effect (pre- and post-therapy measures were given only four weeks apart) or to motivational effects (particularly as the children and their parents had invested a considerable amount of time in the study). However, these factors cannot account for differences between the two groups as both groups were treated in the same way. Unfortunately, the children were not randomly assigned to groups and although the authors claim the groups were matched for IQ and language on the Token Test, a t-test on their scores on the Token Test gives a p-value between 0.1 and 0.2. This is too low to assume that the two groups do not differ as p-values of at least 0.5 should be obtained before groups are considered "matched" (Frick, 1995). This is particularly important given that the group who made the most progress began with the lower scores and therefore had more potential for improvement. Hence it is possible that the low-scoring children were assigned preferentially to the modified speech group and the results are due to regression to the mean. The weaknesses in the study design mean it cannot be taken as a definitive efficacy study and therefore cannot provide strong evidence for the "temporal processing deficit" theory of SLI. Also, as discussed in Chapter 1, it would be surprising if this type of therapy is effective for children with SLI over the age of 8 years as Bernstein and Stark (1985) found that auditory processing difficulties had resolved by this age. For this reason, an analysis of the effects of age on outcome would also be informative.

Despite these limitations, Tallal and colleagues took the results of their (1996) studies to be sufficient proof of the efficacy of their method and proceeded to Phase 4 of the R+S model (Tallal et al., 1998; Tallal, 2000). These two studies involved over 500 children aged 4-14 years who all scored at least one standard deviation below the mean on at least one standardized language test. This was the only criterion for inclusion in the study and the children had a wide range of diagnoses, including SLI. They used the Fast ForWord software for 1hr 40mins per day, 5 days per week for 6-8 weeks. Because this study aimed to establish the effectiveness of the program for a wider range of children (at Phase 4), control groups were not used (although this assumes that efficacy at Phase 3 has been proven). They report that approximately 90% of children who "complied with the study protocol" showed significantly improved performance (at least one standard deviation change from pre-training to post-training) on standardised speech, language or processing measures regardless of the clinical measure chosen. This is the case regardless of diagnosis. On average, skills improved by 1.5 years following 6 weeks of training. However, they fail to say what proportion of the 500 children originally included in the study failed to "comply with the study protocol". The graphs showing the change from pre- to post-therapy only show 171 participants, leaving 329 children unaccounted for. Thus without further information about these children, it is impossible to give any meaningful interpretation to the results.

Independent case study investigations of the Fast ForWord software are reported in a Special Forum in the American Journal of Speech-Language Pathology (2001). This includes three studies investigating language progress following Fast ForWord intervention (Gillam, Crofford, Gale & Hoffman, 2001; Loeb, Stoke & Fey, 2001; Friel-Patti, DesBarres & Thibodeau, 2001). These studies all confirmed the finding that the majority of children using the program make some progress with some areas of language although these changes were less dramatic than in Tallal et al.'s (1996) original study and importantly the children with the most severe language impairments appeared to benefit the least (Gillam et al., 2001; Friel-Patti et al., 2001). These studies also address some of the concerns raised in the discussion above regarding the use of age equivalent scores and the lack of data regarding maintenance of gains. Friel-Patti et al. (2001) found that while age equivalent scores improved, these changes were not clinically significant (i.e., the change in scores did not exceed the standard error of measurement of the standardised tests) and Loeb et al. (2001) found that only half of the gains on standardised measures were maintained three months after the intervention was completed. The core hypothesis of the Fast ForWord program (that the children's language progress is due to their improved auditory processing) is also brought into question by two of these studies: Loeb et al. (2001) found that those children who did not make progress with the auditory processing games, still made progress with their grammar while Gillam et al. (2001) found very similar changes in language performance for children using a different set of language programs but without modified speech. They suggest that the changes in performance may be due to improved attention, listening and response rates (engendered by both programs) rather than improved auditory processing due to the acoustic modifications of the Fast ForWord program.

An independent randomised control trial, with 'blind' assessment also compares the language progress of children (aged 6-10 years) using Fast ForWord with those using other computer-based language programs (Cohen, Hodson, O'Hare, Boyle, Durrani, McCartney, Mattey, Naftalin & Watson, 2005, in press); however, it also includes a control group. All three groups continued with their regular speech and language therapy and school regimes, but only the two experimental groups received additional computer-based intervention. In this study, all three groups made significant gains in language scores, but there was no additional effect for either computer intervention. The authors therefore propose that the progress seen was either as a result of the ongoing intervention received by all the children, or a practice effect, or (in the case of expressive language) due to measurement error. They therefore conclude that Fast ForWord provides no additional benefit to children with severe receptive and expressive SLI over and above the benefit gained from their current therapy and educational support.

In summary, the Fast ForWord approach has advantages over many of the other methods discussed so far because it is explicitly based on theory and it has undergone testing at Phases 1 to 4 of the R+S model. However, the original Phase 3 studies have several weaknesses and independent case studies question some of their findings. A recent randomised control trial with 'blind assessment' indicates that Fast ForWord provides no additional benefit over standard therapy and educational support.

8.5 Metalinguistic and cognitive approaches

The intervention methods discussed in this section differ from those discussed previously, as they do not focus purely on behaviour but also on the cognitive processes underlying language learning. They provide explicit teaching of language often in the context of specific visual cues to aid the child's learning. Studies in this area are in the early stages of the R+S model (mostly Phase 1, as they rarely include experimental control) but are beginning to address gaps in the literature. In particular, they focus predominantly on school-aged children with SLI who often also have receptive language difficulties, although the majority of the studies still aim to improve their expressive language.

Intervention for vocabulary has been investigated at Phase 2 in three studies; one focuses on receptive vocabulary (Parsons, Law & Gascoigne, 2005) and two on expressive vocabulary (McGregor & Leonard, 1989; Hyde Wright, 1993). All three studies focus on teaching the children additional semantic and phonological information associated with the targeted words and the two aimed at expressive vocabulary also teach semantic and phonemic strategies for word retrieval. Parsons et al. (2005) taught vocabulary from the Year 4 Maths curriculum to two children with SLI (aged 8;10 and 9;5), including a variety of parts of speech: nouns (concrete and abstract), verbs and adjectives. The two studies focusing on word retrieval are also with school aged children (aged 9;1 and 10;5 in McGregor and Leonard's (1989) study and four children aged 7;2-8;8 in Hyde Wright's (1993) study) but focus exclusively on concrete nouns. These three studies all suggest that the intervention methods used are efficacious, but we now require further studies at Phase 3 to confirm these indications.

Meta-linguistic approaches to teaching syntax to children with SLI were initially investigated by Lea (1965; 1970); these indicated that colour-coding the parts of speech (using the Colour Pattern Scheme) could help children with "receptive aphasia" (probably Landau-Kleffner syndrome) to learn to produce written language despite extremely limited comprehension and expressive spoken language. Kaldor (1999; 2001) describes use of coloured shapes (Spotlights on Language Communication System) to aid language development in children with SLI, some of whom may have characteristics associated with the autistic spectrum. Unfortunately the evidence for both the Colour Pattern Scheme and Spotlights is anecdotal and no studies have been carried out into their efficacy. Another system of colour coding (Colourful Semantics, Bryan, 1997), colour codes the thematic roles in a sentence in order to help the child identify thematic roles and use this knowledge to create a variety of argument structures. Several case studies have been carried out using this method (Bryan, 1997; Spooner, 2002; Guendouzi, 2003) but none of them include experimental control and therefore should be considered as Phase 1 evidence (R+S model). Bryan's (1997) original study shows some evidence of the efficacy of this system for a child aged 5;10. After three months of intervention, his score on a simple test of expressive language had increased by 12-18 months, the majority of his sentences contained the correct argument structure and he used more verbs. Spooner (2002) indicated the method was effective for one child (aged

6;3) who used more argument and adjunct phrases after 5 months of intervention. Another child (aged 9;9) seemed to benefit less, but both children improved their use of conjunctions, verb morphology and pronouns and improved their ability to retrieve known words. They also both showed progress in formal language tests. In the absence of any experimental control it is difficult to know how much of the progress is directly related to the intervention, especially given that they were both enrolled in a language unit and other factors may have led to the progress in their language. Guendouzi (2003) considers the change in expressive language levels in two children with SLI as measured by a LARSP analysis (Crystal, Fletcher & Garman, 1976; Crystal, 1982). She found that one (aged 7;0) made some progress while the other (aged 6;10) did not.

A further system, which uses visual cues to make the structure of language explicit, was developed by the author ('Shape Coding', Ebbels & van der Lely, 2001; Ebbels et al., 2002) and uses a combination of shapes, colours and arrows to indicate phrases, parts of speech and morphology respectively. Phase 2 investigations of this system used four case studies (aged 11-14 years) in a multiple baseline design and examined its effectiveness at improving comprehension and production of passives and 'wh' questions (Ebbels & van der Lely, 2001) and comprehension of the dative alternation (Ebbels et al., 2002). Three of the four children showed significant progress in both their comprehension and production of passives, and of these three, two showed significant progress in their comprehension of the ditransitive construction. Only two had difficulties comprehending 'wh' questions pre-therapy and both showed significant progress in this area. All four children showed short-term progress with the production of 'wh' questions, but only one child maintained this at a significant level. Chapter 9 is a randomised control trial (at Phase 3) which compares the efficacy of this system with an alternative (semantic) intervention method and also with a control therapy.

Three group studies (at Phase 3 of R+S model) of metalinguistic methods have already been carried out. The first (Zwitman & Sonderman, 1979) investigated whether using picture cards with coloured dots to show sentence order (in conjunction with imitation and modelling) was effective at improving the use of two to four word combinations by children with SLI aged 3;4-4;4. They found that the experimental group made more progress than the control group (although 5/11 of the controls also made significant progress). Another study with much older children (aged 9;0-12;1) targeted the use of subordinating conjunctions (Hirschman, 2000). This is potentially an important study as controls are provided and the children are of an age which is rarely studied. However, although the children were described as having SLI, they do not meet the standard criteria, as their average *verbal* IQ was over 100. This study is therefore of little relevance to this review. The third study at Phase 3 considered comprehension of narratives (Dixon, Joffe & Bench, 2001) in eight children with SLI aged 9-15 years, comparing the effects on oral comprehension of 'traditional therapy' versus 'Visualising and Verbalising' (Bell, 1987). The children made progress with both types of therapy but there was no additional benefit of using 'Visualising and Verbalising'. This study is in the confirmatory stage of Phase 3 of the R+S model as it is an efficacy study comparing a new treatment with a traditional treatment. However, this comparison is premature, as the efficacy of 'traditional therapy' has not yet been proved. Failure to use a control group means that this study cannot speak for the efficacy of either type of therapy as two therapies of unknown efficacy are compared. However, this study could be used at Phase 1 to indicate that both traditional therapy and 'Visualising and Verbalising' merit further investigation with an efficacy study involving a control group.

8.6 Summary and discussion

Published investigations into the efficacy / effectiveness of different methods of intervention fit very different stages of the R+S model. Investigations of grammar facilitation methods have proceeded through many of the Phases and have generally been found to be efficacious. Imitation and modelling approaches have proceeded through Phases 1 to 3 of the R+S model. At the confirmatory stage of Phase 3, they have been compared to each other and imitation has been found to be more effective for learning novel derivational morphemes (Connell, 1987; Connell & Stone, 1992), whereas modelling has been found to be more effective for learning the subject pronoun *they* and a novel syntactic rule (Courtwright & Courtwright, 1976; Courtwright & Courtwright, 1979). Published studies of recasting and expansion have proceeded straight to the Phase 3 confirmatory stage and have been compared with imitation. The children in these studies produced the target forms sooner in their conversational speech with recasting than imitation therapy (Camarata & Nelson, 1992; Camarata et al., 1994; Nelson et al., 1996). Some studies have used a combination of facilitation methods and have found modelling and recasting together to be efficacious, both when delivered by a parent and a clinician, although more reliable progress was seen with the clinician (Fey et al., 1993; 1997).

Studies of grammar facilitation methods have focused exclusively on expressive language, with children who are predominantly under the age of 7 years, many of whom have expressive language difficulties only. They implicitly assume that children can infer the rules of grammar from hearing repeated examples of a target form, i.e., they assume that the children have normal language learning mechanisms, but require more focused exposure to the target forms.

Studies by Tallal and colleagues using the Fast ForWord programme also assume the children have normal language learning mechanisms but have difficulties processing rapidly changing sounds. Hence, they modified the speech signal in order that the children can access the linguistic forms and infer the rules. Studies in this approach have proceeded through Phases 2 to 4 of the R+S model with a wide range of children who vary in both age and diagnosis. The research at Phase 3 is at the confirmatory stage and compares two types of therapy, one with and one without modified speech. However in the original Phase 3 studies, neither of these methods were compared to a control group, thus an important stage was missed. This lack of a control group means that Fast ForWord therapy should not have been be assumed to be efficacious at Phase 3 and further testing of the method at Phase 4 was premature. Indeed, an independent study at Phase 3 indicates that Fast ForWord may not provide additional therapeutic benefit to children with severe receptive and expressive SLI.

Metalinguistic methods of intervention do not necessarily assume the children have normal language learning mechanisms. They provide the children with cognitive strategies for learning language, hypothesising that they can use their superior cognitive skills to support their weak linguistic skills. Probably for this reason, these studies usually involve school-aged children. The majority of the studies focus on expressive language although many of the participants also have receptive language impairments. These studies are mainly at Phase 1 of the R+S model as they involve single case studies with no experimental control. Of the two studies at Phase 3 (Hirschman, 2000; Dixon et al., 2001), the first involved children who do not appear to have SLI and the second compared two therapies but did not involve a control group, hence it is impossible to know whether either therapy was efficacious.

Conclusions regarding the efficacy of different methods of intervention need to consider the characteristics of the individual children receiving the intervention and the target of the intervention. The aim of intervention studies is surely to be able to identify which methods are best, for which targets and for children with which characteristics. One major factor in efficacy of different therapy methods is likely to be age. Older children have more cognitive resources and may therefore respond better to intervention, especially meta-linguistic and cognitive approaches. On the other hand, older children with SLI may have more severe difficulties, which have not resolved with the intervention they have received to this point, and therefore they may show less progress. Studies involving younger children may well include some children who have delayed language and not SLI. Such children are likely to respond best to those approaches which assume normal language learning mechanisms. Indeed, response to different intervention methods may be a useful method of differential diagnosis.

Another factor to consider when comparing different intervention methods is the target of intervention. For example, children may improve their production of language better with one method and their receptive language better with another. This may also vary according to whether the children have purely expressive difficulties or whether they also have receptive difficulties.

Figure 8.1 summarises the studies described above according to the age of the children and the broad target of intervention. The bars show the age range of the children, the brackets at the end of each bar show the number of children in the study and dashed lines indicate studies without sufficient controls or evidence of progress to conclude that the intervention was efficacious.

If we consider only those studies with experimental control and evidence of efficacy, only two studies (by Ebbels and colleagues) involve participants over 11 years of age and only nine studies involve children over 7 years of age (3 focusing on vocabulary, 4 on expressive morphology or syntax, 1 on comprehension of syntax and 1 on argument structure). This is despite extensive evidence that SLI persists well beyond the early primary years and into adolescence (Aram & Nation, 1980; Aram, Ekelman & Nation, 1984; Silva et al., 1987; Beitchman, Wilson, Brownlie, Walters & Lancee, 1996; Stothard, Snowling, Bishop, Chipchase & Kaplan, 1998; Johnson, Beitchman, Young, Escobar, Atkinson, Wilson, Brownlie, Douglas, Taback, Lam & Wang, 1999; Law, Boyle, Harris, Harkness & Nye, 2000; Botting et al., 2001; Conti-Ramsden, Botting, Simkin & Knox, 2001). Chapter 9 therefore aims to address several gaps in the literature. It is the first controlled group study investigating the efficacy of metalinguistic intervention for argument structure. It also involves children over 11 years of age, all of whom have both receptive and expressive language impairments, thus answering the call from Law et al. (2004) for "further research investigating the effects of intervention for children with receptive language disorders". It therefore aims to provide some evidence in favour of the use of metalinguistic approaches for improving language skills with older children with persistent receptive and expressive SLI.

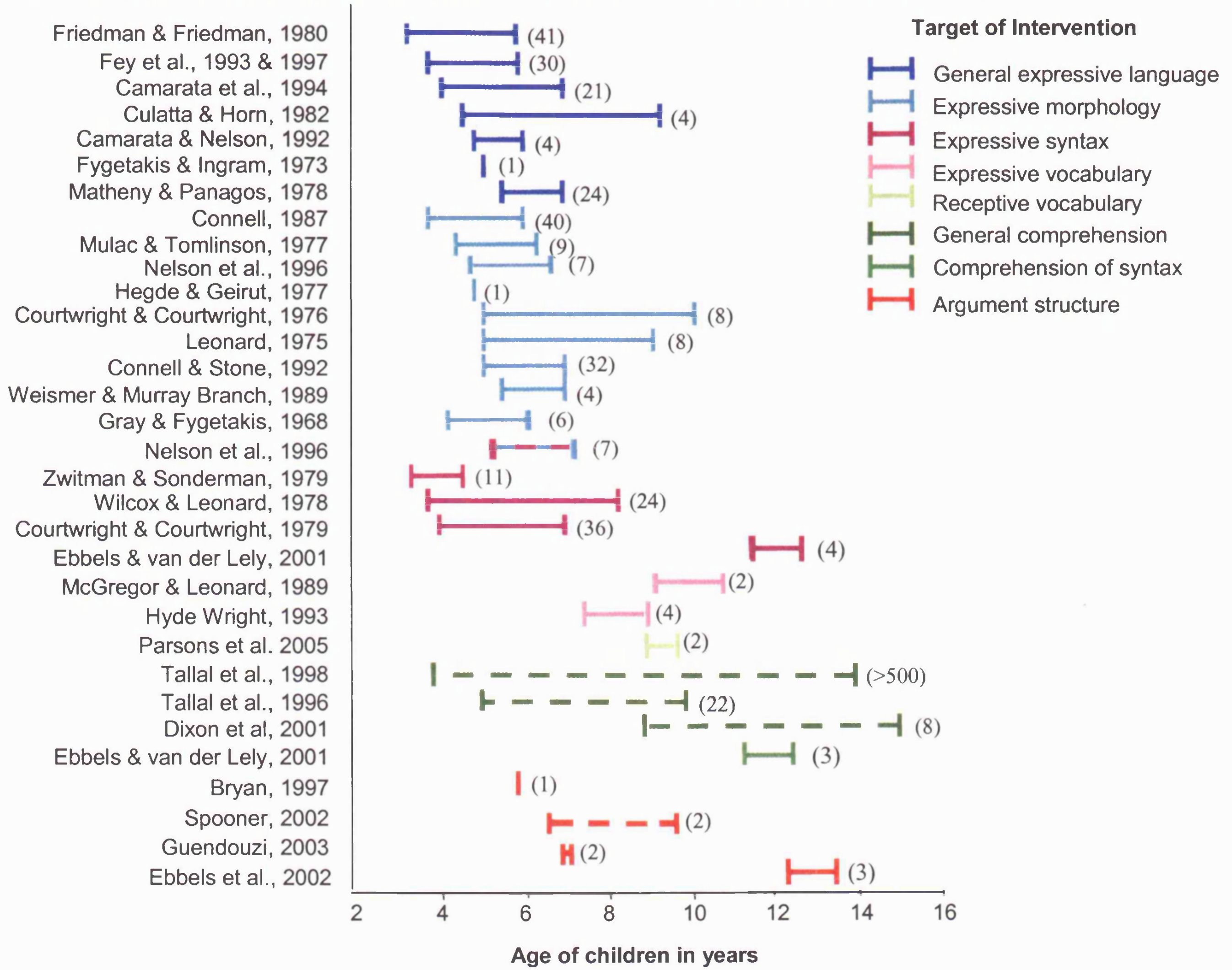


Figure 8.1: Intervention studies for SLI claiming progress in particular areas, showing ages of children and intervention area, by colour. (Studies lacking sufficient control are shown with dashed lines)

CHAPTER 9 INTERVENTION FOR ARGUMENT STRUCTURE

9.1 Introduction and aims of chapter

This chapter investigates the effectiveness of intervention for argument structure using two metalinguistic approaches with secondary-school aged children with receptive and expressive SLI. The intervention focuses on two areas of argument structure where the children with SLI in Chapter 5 had significantly more difficulties than their controls: change of state verbs and omission of obligatory arguments, particularly where three arguments are required. This chapter therefore focuses on three groups of verbs: change of state verbs, change of location verbs and verbs which undergo the locative alternation. The latter two groups of verbs are included as they frequently require three arguments.

In the discussion section of Chapter 5, I outlined several possible methods for improving the performance of the children with SLI in these areas and discussed the possible outcomes of these intervention methods in Chapter 7. This chapter will compare three methods of intervention: one focused mainly on semantics, one on syntax and a control intervention unrelated to argument structure.

9.2 Study design

9.2.1 Participants and assignment to groups

27 children with SLI (aged 11;0-16;1) participated in the study, 10 girls and 17 boys. All spoke English as their only language, attended a residential school for children with severe specific language impairment and matched the criteria for the study:

- Expressive *and* Receptive Language scores on the CELF-3 of –1.5 SD below the mean or lower,
- Performance IQ scores no lower than –1.5 SD below the mean (measured using the mean of the Matrices and Pattern Construction subtests of the BAS-II)
- A gap of at least 1.5 SD between Total Language score on the CELF-3 and Performance IQ.

The performance IQ criteria were relaxed compared to the previous studies in this thesis to –1.5 SD below the mean because there is no indication that performance IQ levels affect outcome of intervention (Cole et al., 1995; Notari et al., 1992; Botting et al., 2001). Cole et al., (1995) also provide evidence that performance IQ scores tend to decrease with age in children with SLI, possibly due to increasing verbal mediation in supposedly 'non-verbal' tasks used at older ages. Given the age of the children in the current study and the severity of their language impairments, their performance IQ scores may have dropped and those who now score between –1 and –1.5 SD may have scored above –1SD in the past. Eleven of the children participated in the studies reported in previous chapters of this thesis; the remaining sixteen were recruited solely for the intervention study. All children completed the intervention and all testing stages.

The children were randomly assigned to the three therapy groups (9 children in each) using the random number function on an Excel spreadsheet. A power calculation shows that for each group of 9 children the chance of finding a medium effect size of d=0.5 (Cohen, 1988) is 44% (1-tailed) or 32% (2-tailed). Cohen (1988) recommends aiming for power of 0.8 (an 80% chance of finding a significant effect of a particular size). However, this would require more than 30 children in each group which was not practical for the current study, given that the intervention was provided by only one therapist. The low power of this study must therefore be borne in mind when interpreting the results. Failure to find a significant effect in any group could be due merely to a lack of power. On the other hand, any significant results which are found are likely to involve large effects.

The scores of the individual children and group means on language tests are reported in Appendix E and group means in Table 9.1. One-way ANOVAs (or non-parametric equivalents for CELF-3 scores) showed the three groups were equivalent in age and had similar language scores. The only exception to this was z-score on the BPVS where the children in the Shape Coding therapy group had significantly lower scores than both the Semantics therapy group (p=0.035) and the Control therapy group (p=0.001). However, they did not differ significantly in raw score on the BPVS.

9.2.2 Pre and post-tests

The test for argument structure used before and after intervention was of the same format to the production test described in Chapter 4. The children watched 54 video scenes depicting actions involving 18 different verbs (three for each verb) and described what was happening using a given verb. The video scenes are listed in Appendix F. The videos were presented in the same random order to each child, but the order was changed each time the test was repeated during the year.

Table 9.1: Summary of subject details by therapy group

			Semantics therapy (Sem)	Shape Coding therapy (SC)	Control therapy (Cont)	Summary of statistics
	Receptive	Mean *(SD)*	-2.2 *(0.3)*	-2.1 *(0.4)*	-2.1 *(0.3)*	Sem = SC = Cont (p=0.73)
	Language	Range	-2.4 to -1.8	-2.4 to 1.1	-2.4 to -1.4	
CELF-3	Expressive	Mean *(SD)*	-2.3 *(0.2)*	-2.1 *(0.4)*	-2.2 *(0.3)*	Sem = SC = Cont (p=0.45)
z-scores	Language	Range	-2.4 to -1.9	-2.4 to 1.3	-2.4 to -1.5	
	Total	Mean *(SD)*	-2.4 *(0.0)*	-2.4 *(0.0)*	-2.3 *(0.1)*	Sem = SC = Cont (p=0.09)
	Language	Range	-2.7 to -2.4	-2.5 to -1.3	-2.4 to -2.0	
Age	(in months)	Mean *(SD)*	162 *(14.9)*	166 *(16.5)*	153 *(15.0)*	Sem = SC = Cont (p=0.19)
		Range	146 to 188	140 to 193	132 to 174	
Performance		Mean *(SD)*	-0.6 *(0.7)*	-0.1 *(1.0)*	-0.7 *(0.6)*	Sem = SC = Cont (p=0.053)
IQ		Range	-1.45 to 0.75	-1.4 to 1.6	-1.3 to 0.5	
Raw	BPVS	Mean *(SD)*	98 *(13)*	90 *(14)*	99 *(12)*	Sem = SC = Cont (p=0.22)
scores		Range	76 to 119	66 to 106	78 to 118	
	TROG	Mean *(SD)*	15 *(2)*	14 *(3)*	15 *(2)*	Sem = SC = Cont (p=0.335)
		Range	12 to 17	8 to 17	11 to 18	
	BPVS	Mean *(SD)*	-1.4 *(0.4)*	-2.0 *(0.6)*	-1.3 *(0.4)*	SC < (Sem = Cont) (p<0.04)
z-scores		Range	-2.3 to -0.8	-2.7 to -0.9	-1.7 to -0.6	
	TROG	Mean *(SD)*	-1.4 *(0.6)*	-1.7 *(0.8)*	-1.5 *(0.7)*	Sem = SC = Cont (p=0.60)
		Range	2.2 to -0.7	-3.0 to -0.7	-2.3 to -0.1	

The test was designed to include a range of argument structures, particularly those where the study in Chapter 5 showed the children with SLI had more difficulties than their controls: change of state verbs and verbs with three obligatory arguments. A summary of the verbs used is given in Table 9.2. The test includes six change of state verbs, six change of location verbs (four of which have three obligatory arguments, shown in bold in Table 9.2) and six verbs which undergo the locative alternation (all of which require a prepositional phrase or particle in the change of location construction). Within each of these broad groups, the verbs were split into pairs (A and B) with closely related meanings and argument structures (identified using Levin, 1993). A Wilcoxon signed ranks test showed the A and B verbs did not differ in their written frequencies as identified from the CELEX database (Baayen, Piepenbrock & Gulikers, 1995) ($W=81.5$, $n_1=9$, $n_2=9$, $p=0.75$).

Table 9.2: Verbs used in test

Change of state		Change of location		Alternating	
A	cover	A	spill	A	clear
B	fill	B	pour	B	empty
A	surround	A	**hang**	A	wipe
B	block	B	**lean**	B	sweep
A	decorate	A	**put**	A	wrap
B	build	B	**place**	B	stuff

Table 9.3 summarises the therapy and testing timetable. All children in the study were assessed at the beginning of the academic year at the start of the study. Five children were randomly chosen from each of the three therapy groups to receive intervention in Phase 1 (Autumn term) and all children were then re-assessed at the end of the Phase 1. The remaining four children from each of the three groups then received intervention in Phase 2 (Spring term) and all children were re-assessed again. After a further term, those children who had received therapy in Phase 2 were assessed again to provide a follow-up measure. In order to establish whether any change with therapy was specific to those verbs taught or whether it generalised to other verbs, the children in the Semantic and Shape Coding groups were tested on all verbs but only taught half of the verbs. In Phase 1, three children from each group focused on A verbs and two on B verbs; in Phase 2, two children from each group focused on A and two on B verbs.

Table 9.3: Timetable for testing and therapy

	Phase 1 children	Phase 2 children
Test 1: Sept	pre-therapy test	baseline test
Sept-Dec	**therapy**	
Test 2: Dec	post-therapy test	pre-therapy test
Jan-Mar		**therapy**
Test 3: Mar	follow-up test	post-therapy test
Test 4: July		follow-up test

The author provided the intervention to all participants. An assessor blind to the treatment group of the children carried out all assessments and assigned codes to all children (different at each testing point). Both the assessor and the author transcribed the production data and labelled this only with the child's code. The author then carried out the scoring on the coded data and hence was unaware of the identity of the children when carrying out the scoring. Only after scoring was complete was the author given the codes in order to match the children's scores at different testing points and continue with further analyses.

9.2.3 Intervention methods

All participants in the study attend a specialist residential school for children with SLI and therefore received specialist teaching and therapy throughout the study. Staff in the school were asked not to carry out specific focused work on argument structure (or the control therapy) during the period of the study. Random assignment to groups should balance out other factors which may contribute to change in scores such as focus of class work and other intervention as the children should come from a range of classes and work with a range of speech and language therapists. The control group received an equal amount of therapy from the author as the argument structure therapy groups in order to remove any possible non-specific benefit of receiving additional intervention from the author. The Control therapy was on an unrelated topic, aiming to improve the children's ability to form inferences when comprehending texts along the lines of Yuill and Oakhill (1988) and hence involved no focus on argument structure. All children in the study received nine individual therapy sessions with the author, lasting approximately 30 minutes each, once weekly, in their normal school setting.

9.2.3.1 Semantic therapy

The Semantic therapy was based on the theories of Pinker (1989) and Jackendoff (1990) that the syntactic constructions used with verbs can be projected from their semantics. Pinker (1989) also sees verb semantics as crucial for predicting whether a verb can undergo an alternation, as the language specific narrow-range rules depend on detailed semantic information. Thus the aim of the Semantic therapy was to provide the children with detailed information about the semantic representations of the targeted verbs. The focus of therapy was both on the thematic core of the verb and also on the detailed semantic information underling the use of narrow range rules. In delivering this intervention, the author aimed to provide no syntactic information regarding the argument structure of the verb by only using the verbs in the gerund form e.g., "this is pouring", "show me sweeping", "is this filling?" This was done so that the children could not use associative pairing of the syntactic construction with the verb (Tomasello, 2000b) but would have to rely purely on verb semantics. Thus (as discussed in Chapter 7) this method of therapy should improve targeted change of state verbs and the use of alternations, but any effects are unlikely to generalise to untargeted verbs or improve the use of obligatory arguments.

One or two verbs were targeted each session. Initially the author and child jointly devised a written definition for the target verb with as much detail as possible. For example, the definitions for *fill* and *pour* were similar to the following:

filling	***pouring***
make something full to the top	*liquid or lots of things* *go down together* *to a new place* *container is tipping*

Then the author and child took turns to act out an event using a variety of props. The other person then went through each point of the definition deciding if the event matched the definition and identifying each of the participants in the event. The author deliberately enacted a variety of events that violated one or more points of the definition to ensure that the child had a full understanding of the verb. In the examples given, several children initially accepted events as *filling* even when the container only became half-full or *pouring* when only one object fell out of a container. In the later sessions, several verbs were considered together such that their meanings could be compared and contrasted. The author / child acted out a single event which could be described using a variety of verbs and the other person had to decide which verbs could or could not be used to describe the event and why.

In order to verify that the author did not use the verbs in sentences during the sessions, one session was recorded. The analysis of this session showed that neither the author nor the child used the verb which was the direct focus of the therapy in a sentence. Nevertheless, both the adult and the child used the verbs *cover* and *put* (target verbs in other sessions) in sentences when describing other verbs. However, these were not always in the correct argument structure. The use of *cover* in a sentence was initiated by child's description of *wrap* as "**cover** something, **cover** around" which the adult then copied for clarification. The child also used *put* in a sentence 3 times (twice correctly and once incorrectly) e.g., "if that like this and **put** it here and **put** it like, we are the best". The author used *put* 18 times in the correct argument structure and 4 times with omitted arguments, usually because she wanted the child to fill in the missing argument, thus intonational cues were present to indicate that an argument was missing (e.g., "I put the cloth…", "I put something…"). This shows that even when the verbs are used in sentences, these sentences do not necessarily have the correct argument structure, especially when used in spontaneous speech. The adult's use of *put* in sentences (due to its status as a generic verb for describing change of location) may have contaminated the relatively 'pure' Semantic therapy for this verb, but similar levels of contamination are unlikely to have occurred for the other verbs.

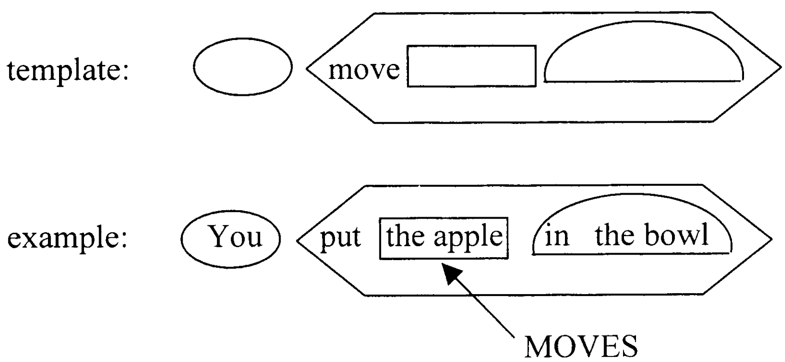
9.2.3.2 Shape Coding therapy

Shape Coding therapy was developed for teaching syntax and morphology to children with SLI. It has been used previously for teaching syntactic movement in 'wh' questions and passives (Ebbels & van der Lely, 2001) and also for the comprehension of the dative alternation (Ebbels et al., 2002). Sentences are 'coded' with shapes, colours and arrows to make the syntactic structure of English concrete, permanent and available to inspection and discussion. Different parts of speech are underlined with different colours and the phrases of the sentence are enclosed in shapes. The different shapes correspond to different kinds of phrases and are linked with questions such as *Who* and *Where*, and symbols to represent these questions (examples are shown in Appendix G). For example, a Verb Phrase is surrounded by a hexagon and linked with the question *What doing*. Arguments of the verb appear inside the VP hexagon and adjuncts appear outside it. Verb morphology is also coded with a system of arrows, but these were not used during the argument structure therapy.

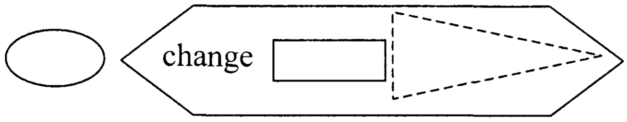
The therapy method for the study focused on explicitly teaching the links between syntactic constructions and meaning. This is based on the common ground between lexical and construction grammar theories of argument structure, In terms of the lexical theories of argument structure the links taught are between syntactic constructions and the thematic cores of the verb. In terms of the construction grammar theory the links are between constructions and construction meanings.

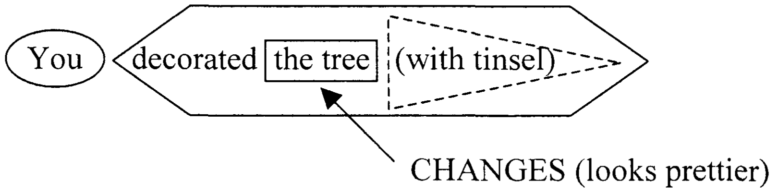
Change of location verbs were linked to the construction: Subject, Verb, Object, Prepositional Phrase (including *to* – answering the question *Where*) and the change of state verbs to the construction: Subject, Verb, Object, optional Prepositional Phrase (including *with* - answering the question *How*). The construction templates were associated with the construction meaning (or thematic core) *move* or *change* indicating the type of verbs associated with the construction (moving or changing verbs) and hence the role of the object. Obligatory arguments have solid lines and optional arguments have dashed lines.

Change of location templates / examples

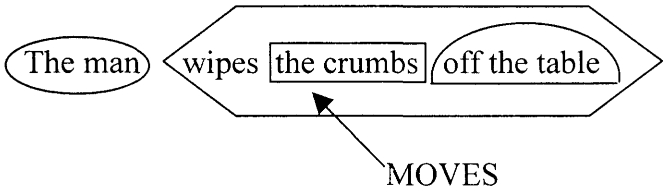


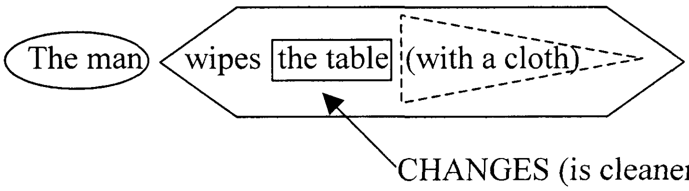
Change of state templates / examples

template: 

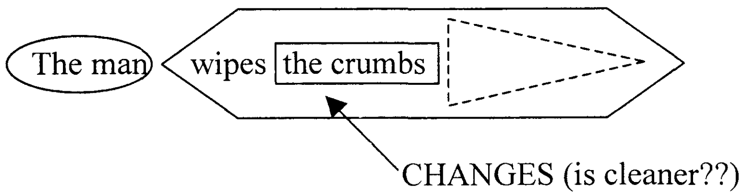
example: 

The use of such constructions with alternating verbs can then also be demonstrated, as these are associated with two thematic cores (or construction meanings) and two constructions. For example:





The templates can also be used to show why omission of the prepositional phrase with the change of location construction changes the meaning:



This construction implies the man cleaned the crumbs, which is clearly not intended. Thus the children can see that if they wish to imply *the man removed the crumbs*, they need to use a prepositional phrase.

Generally, the first two sessions focused on change of location verbs, the next four on change of state verbs and the final three on alternating verbs, although if the child had particular difficulties with either change of location or change of state verbs, an extra session focussed on that area, reducing the number of sessions spent on alternating verbs.

9.3 Results[13]

The children's individual results from all tests are shown in Appendix H. Initially, the children's performance at Test 1 (pre-therapy for children in Phase 1 and baseline for children in Phase 2) was analysed in order to establish whether they showed a similar pattern of results to those in Chapter 5. Spearman's rank correlations (1-tailed) showed the argument structure scores at Test 1 correlated significantly with raw scores on the BPVS ($r=0.53$, $p=0.002$) and the TROG ($r=0.46$, $p=0.007$) but not with performance IQ ($r=0.04$, $p=0.41$).

A Wilcoxon signed ranks test by verb of the ability to use the correct construction for change of state and location verbs was significant ($W=196$, $n_1=18$, $n_2=18$, $p<0.001$); the children scored near ceiling for the change of location verbs and performed significantly worse on change of state verbs. They also omitted more obligatory prepositional phrases than objects ($T=306$, $n=25$, $p<0.001$). Thus this larger group of children with SLI (some with lower performance IQs) show very similar results to the smaller group in the study in Chapter 5.

Comparisons of the initial performance of the children in the three therapy groups at Test 1 showed no difference between the three groups on the overall proportion correct ($F,(2,24)=0.59$, $p=0.56$, $\eta^2=0.05$) or on use of the incorrect construction ($F(2,24)=2.43$, $p=0.11$, $\eta^2=0.17$) or omitted prepositional phrases ($F(2,24)=0.15$, $p=0.86$, $\eta^2=0.01$).

The remainder of the results will be based on the children's scores relative to the time they received intervention: pre-therapy, post-therapy and at follow-up. A summary of the results at these times is shown in Table 9.4.

Inspection of Table 9.4 and Appendix H reveals aspects of the data which must be considered before commencing analysis of the relative benefits of the three intervention methods. Although the children were randomly allocated to groups and there is no statistical difference between the group means pre-therapy, the groups do not have identical scores pre-therapy and the variance and range in some groups is larger than in others. Thus a simple comparison of post-therapy scores is unwise, but comparisons of gain scores (post-therapy minus pre-therapy) for each child may well reduce the effect of these differences. However, some children scored near ceiling pre-therapy and had little room for change while some had very low scores and hence great potential for change. Exploration of the data also revealed four of the low scoring

[13] These results were presented at the International Association of Logopedics and Phoniatrics conference in Brisbane, Australia, 2004.

children to be outliers compared to the rest of the children. While it would be possible to exclude these outliers, they are arguably the children who need the intervention most and therefore removing them from any analysis is unhelpful. However, the combination of a ceiling effect and a few children who score much lower than the others could lead to a potential bias if a simple gain score is used.

Table 9.4: Proportion correct by group and time (relative to therapy)

Group	Time	Mean	*SD*	Range
Semantics	pre-therapy	0.82	*0.11*	0.57-0.94
	post-therapy	0.87	*0.09*	0.65-0.96
	follow-up	0.88	*0.09*	0.74-0.98
Shape Coding	pre-therapy	0.74	*0.22*	0.26-0.96
	post-therapy	0.85	*0.14*	0.57-1.00
	follow-up	0.81	*0.20*	0.41-1.00
Control	pre-therapy	0.86	*0.09*	0.69-0.96
	post-therapy	0.83	*0.15*	0.59-1.00
	follow-up	0.84	*0.08*	0.69-0.94

In order to include the data from all the children without allowing the outliers to bias the results, a "normalised gain score" was used (Hake, 1998). This score measures the actual gain as a proportion of the potential gain for each child i.e.:

$$\frac{(\text{Time 2 score} - \text{Time 1 score})}{(1 - \text{Time 1 score})}$$

This has been claimed to have "maximum dependence on instruction, with minimum dependence on students' preinstruction states" (Meltzer, 2002). These scores were calculated for each child using post-therapy and follow-up scores as Time 2 scores and using pre-therapy score as Time 1 score in both cases. Figure 9.1 shows the mean normalised gain scores from pre-therapy to post-therapy and to follow-up for each of the therapy groups across all verbs (the error bars show one standard deviation). The Semantic and Shape Coding therapy groups appear to have changed positively compared to their pre-therapy scores while the control therapy group has not.

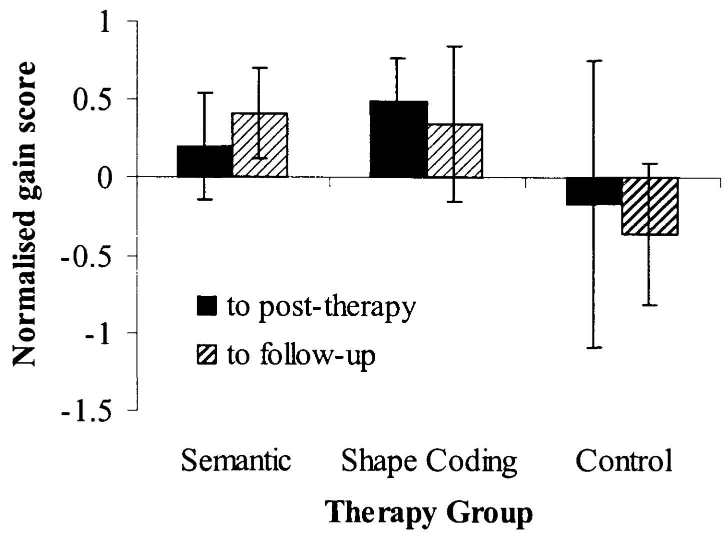


Figure 9.1: Mean normalised gain scores to post-therapy and follow-up (across all verbs)

This effect was confirmed by a mixed design 2x3 ANOVA with time (normalised gain to post-therapy vs. normalised gain to follow-up) as the within subjects variable and therapy group as the between subjects variable. This showed no main effect of time ($F(1,24)=0.13$, $p=0.72$, $\eta^2=0.01$), or interaction of group and time ($F(2,24)=1.01$, $p=0.38$, $\eta^2=0.08$) but did show a significant main effect of group ($F(2,24)=7.34$, $p=0.003$, $\eta^2=0.38$). Post-hoc Bonferroni corrected t-tests showed this was due to a significant difference between the Semantic and Control therapies ($p=0.006$, $d=1.42$) and the Shape Coding and Control therapies ($p=0.002$, $d=1.68$) but no difference was found between the Shape Coding and Semantic therapies ($p=0.582$, $d=0.26$). Averaged normalised gain scores (post-therapy and follow-up combined) were significantly different from zero for both the Shape Coding ($t(8)=3.36$, $p=0.01$, $d=1.12$) and Semantic therapy groups ($t(8)=5.33$, $p=0.001$, $d=1.78$), but not for the Control therapy group ($t(8)= -1.39$, $p=0.20$, $d= -0.46$).

To summarise the results so far, we have seen that both the Semantic and Shape Coding therapies effected a significant positive change whereas the Control therapy did not.

9.3.1 Generalisation to control verbs

Each child in the two argument structure therapy groups was taught only half of the test verbs in Table 9.2, either group A or B. Therefore it is possible to analyse their change in performance on targeted versus control verbs. Mean normalised gains can be seen in Figure 9.2.

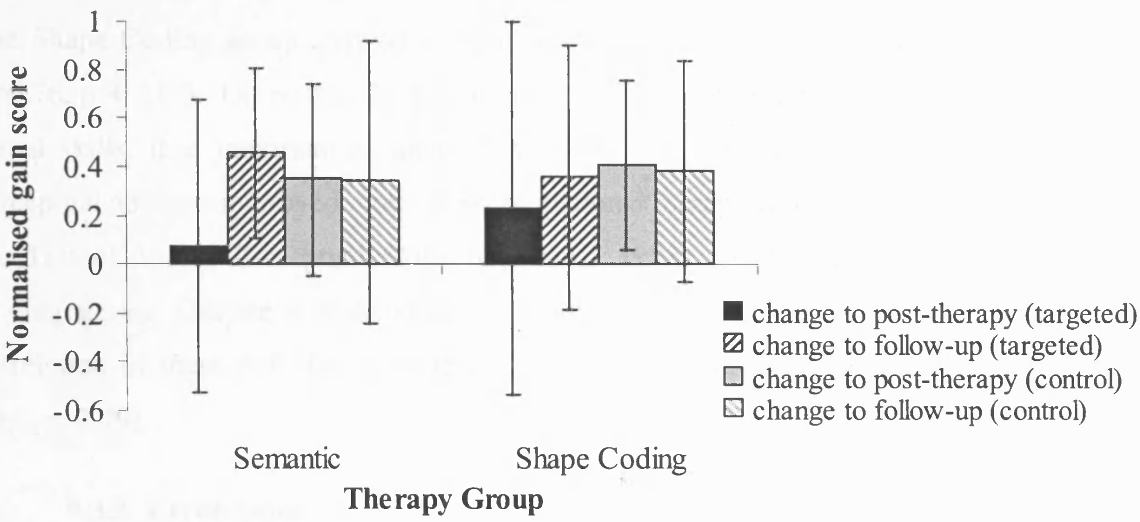


Figure 9.2: Normalised gain in targeted versus control verbs for Semantics and Shape Coding groups

A 2x2x2 mixed design ANOVA with time and verbs (targeted vs control) as within subjects variables and therapy group as the between subjects variable showed no main effects of time (F(1,14)=0.54, p=0.48, η^2=0.04), verbs (F(1,14)=0.64, p=0.44, η^2=0.04) or group (F(1,14)=0.11, p=0.75, η^2=0.01). None of the interactions were significant (p>0.25). This shows that there was no difference in degree of change between the groups or verbs and no effect of whether argument structure was measured immediately after therapy or at follow-up. In order to test whether these gains were significant, the gain scores averaged over post-therapy and follow-up were compared to zero for each group using a one-sample t-test. The normalised gain in targeted verbs was significantly different from zero for the Shape Coding group (t(8)=2.65, p=0.03, d=0.88) and showed a trend towards significance for the Semantic therapy group (t(7)=2.04, p=0.08, d=0.71). The normalised gain score for control verbs was significant for both groups (Shape Coding: t(7)=3.07, p=0.02, d=1.08; Semantics: t(8)=4.89, p=0.001, d=1.63). Therefore we can conclude that improvements for both therapy groups were not just on targeted verbs but generalised to other related verbs.

9.3.2 Correlations

In order to establish whether particular profiles of strengths and weaknesses affect the response to particular therapy methods, correlations were performed between the average normalised gain scores (post-therapy and follow-up combined), age, standardised language tests (raw and z-scores) and performance IQ tests. The Semantic therapy group showed no significant correlations with age or the language tests (r<0.35, p>0.35) but a significant negative correlation with performance IQ (r= -0.69, p=0.04). The Shape Coding group showed a significant correlation only with BPVS raw score (r=0.76, p=0.017). Given that the therapy provided to the Shape Coding group relies on visual skills, it is important to establish whether those children with stronger visual perceptual abilities improved more. The occupational therapists in the school carried out the Test of Visual Perceptual Skills (Gardner, 1988) on all children in the Shape Coding group. Despite a wide range of scores (z-scores from –3.00 to +1.13), the correlation of these with the average normalised gain score was not significant (r= -0.11, p=0.79).

9.3.3 Error types

In the discussion section of Chapter 5, I hypothesised that the Semantic therapy should improve the children's ability to use the correct construction with change of state verbs, but may not improve their use of obligatory arguments. The Shape Coding therapy on the other hand should improve both the use of the correct construction and also the use of obligatory arguments. Very few children omitted obligatory objects at any point in the study, therefore changes in these errors were not analysed. We will consider whether the averaged normalised gain scores for 1) choice of the correct construction and 2) use of obligatory prepositional phrases for each group were significantly better than zero for targeted versus control verbs. The results for the Semantics and Shape Coding groups are shown in Figure 9.3.

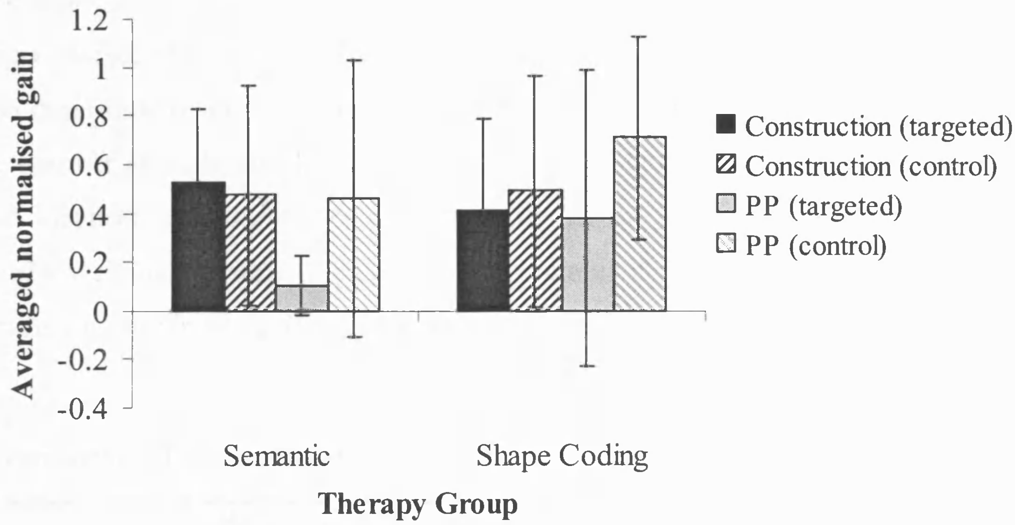


Figure 9.3: Normalised gain scores for use of the correct construction and use of obligatory prepositional phrases

It was not possible to carry out an overall analysis on these data as too few children had valid normalised gain scores on all four measures (due to pre-therapy scores on at least one measure being at ceiling). Thus each measure was considered separately for each group. These analyses showed that the children receiving the Semantic therapy showed a normalised gain significantly different from zero for the choice of the correct construction for both targeted ($t(6)=4.69$, $p=0.003$, $d=1.77$) and control verbs ($t(7)=3.00$, $p=0.02$, $d=1.05$), although the effect size for targeted verbs was larger. They showed no significant improvement in the use of obligatory prepositional phrases on either targeted ($t(4)=0.20$, $p=0.85$, $d=0.09$) or control verbs ($t(5)=2.00$, $p=0.10$, $d=0.81$). The group receiving the Shape Coding therapy also showed a normalised gain significantly different from zero for their choice of the correct construction for both targeted ($t(7)=3.16$, $p=0.02$, $d=1.12$) and control verbs ($t(6)=2.73$, $p=0.03$, $d=1.03$). In addition, they showed significant improvement in the marking of obligatory prepositional phrases on control verbs ($t(4)=3.80$, $p=0.02$, $d=1.70$) but not on targeted verbs ($t(5)=1.53$, $p=0.19$, $d=0.62$).

9.3.4 Error patterns with change of state verbs

In Chapter 5, we saw that a disproportionate number of children with SLI made consistent errors with change of state verbs (choosing to use only the change of location construction with some of these verbs). I hypothesised that both the Semantic and Shape Coding intervention methods should be able to help children progress from this immature pattern to using the verbs as alternating verbs and then finally to limit them to the (correct) change of state form. Hence it is of interest to consider the individual data in order to determine if the children did indeed go through this progression. Table 9.5 shows the number of times any child used any change of state verb consistently with the change of location construction or inconsistently as an alternating verb. The test consisted of six change of state verbs and there were nine children in each group, hence the maximum number in any cell is 54.

Table 9.5: Incorrect choices of construction for change of state verbs (number of children involved), consistent = 3/3 wrong, inconsistent = 1 or 2/3 wrong

	Semantic therapy		**Shape Coding therapy**	
	Consistent	Inconsistent	Consistent	Inconsistent
Pre-therapy	7 (3)	14 (5)	1 (1)	16 (7)
Post-therapy	0 (0)	4 (4)	0 (0)	7 (6)
Follow-up	1 (1)	4 (3)	0 (0)	9 (4)

Both groups showed a reduction following intervention in both the consistent and inconsistent use of the (incorrect) change of location construction. The number of children involved reduced as well as the total number of errors. Because the tests were only done after the end of the intervention it is difficult to establish whether the children did show the progression: consistently wrong → inconsistent → consistently right, as all children who had made consistent errors pre-therapy, made no errors on those verbs post-therapy or at follow-up.

9.4 Discussion

Both groups who received intervention targeted at improving their ability to use argument structure made significant progress in this area. This progress was not only restricted to the specific verbs which were targeted in the intervention, but also generalised to control verbs. In contrast, a control group receiving the same amount and intensity of intervention unrelated to argument structure made no progress in this area. Thus, this study provides strong evidence that both the Semantic and Shape Coding therapy methods were effective at improving the use of argument structure. This shows that intervention for language difficulties can be effective when it is based on detailed analysis of the children's difficulties (Part 1 of this thesis). No previous studies have investigated whether methods such as those used in the Semantic therapy can improve argument structure. On the other hand, three studies have shown that methods similar to Shape Coding can be effective (Bryan, 1997; Spooner, 2002; Guendouzi, 2003). However, none of these studies provided experimental control and this study therefore provides vital evidence that progress is directly related to the intervention. Only a few previous studies have investigated intervention for children with SLI at the sentence level over the age of 10 years. The studies by the author and colleagues (Ebbels & van der Lely, 2001; Ebbels et al., 2002) were series of single case studies and therefore only provide evidence at Phase 2 of Robey and Schulze's model. The two group studies (Tallal et al., 1998; Dixon et al., 2001) unfortunately provided insufficient experimental control and must therefore be regarded as Phase 1 evidence. In contrast, the study in this chapter used a control group who received an equal amount of individual attention but focussed on an unrelated topic (hence constituting a Phase 3 study). They made no progress with argument structure thus allowing us to conclude that the progress shown by the children in the Semantic and Shape Coding therapy groups was a direct result of type of intervention they received.

It is important to investigate whether children with certain pre-therapy profiles made more or less progress than others with the two types of intervention. In this study, the amount of progress made by the children was unrelated to most pre-therapy linguistic and cognitive measures. However, improvement in the children receiving the Semantic therapy was negatively correlated with performance IQ. Thus, the children who had the lower cognitive scores benefited the most. It is possible that these are the children who had previously made less use of observation to refine their semantic representations of verbs and therefore benefited the most from structured work which brought certain semantic features explicitly to their attention. For the children in the Shape Coding group, progress was positively correlated with BPVS raw score i.e., the children with better vocabularies benefited more from the Shape Coding method. This method did not focus in detail on the semantic representations of the verbs but more on which constructions to use with which thematic cores. It is therefore possible that children with better initial semantic representations can benefit more from this method; these are likely to be the children with higher BPVS scores. If this is the case, then those children with lower BPVS scores (and less well defined semantic representations) may well have also benefited from the Semantic therapy. Indeed, given the success of both methods of therapy, the next step would be to establish whether using both methods in parallel could lead to even greater improvements for all children.

Both the groups receiving targeted therapy improved their ability to choose the correct construction for both targeted and control verbs. The Semantic therapy focused purely on refining the children's semantic representations of targeted verbs. The improvement in construction use for targeted verbs therefore indicates that faulty or imprecise semantic representations may have been at fault and that improving these leads to use of the correct construction. This confirms that the children must have access to the linking rules for forward linking, because no focus was placed on which construction to use with these verbs. However, they improved not only on targeted verbs but also on the control verbs; this was not predicted. However, the control verbs were closely related to the targeted verbs both in meaning and in argument structure. Thus, the intervention must have encouraged them to re-analyse the semantic representations of other semantically related verbs which were not specifically targeted. Thus, the focus on the change of state of the Patient in the targeted change of state verbs may have led the children to notice a similar change of state in the closely related control verbs.

The Shape Coding therapy provided less semantic information than the Semantic therapy, but it did focus on the thematic cores of verbs and how these relate to constructions. Thus the children could learn to restrict the change of state verbs only to this construction either through associative pairing or through syntactic bootstrapping. Associative pairing would only apply to targeted verbs but the children also made progress with control verbs too. Thus, they must have learned more general rules which could be applied to a wider range of verbs. I hypothesise that the Shape Coding therapy made them more aware of the constructions used by adults and how this relates to particular thematic cores, thus enabling them to use syntactic bootstrapping for other verbs (outside the intervention sessions) and thereby revise the stored thematic cores for these other verbs.

As far as omissions of obligatory arguments are concerned, as predicted only the group receiving the Shape Coding therapy made significant progress. Thus, focusing on the semantic participants in an event (as in the Semantic therapy) is insufficient for reducing omissions of obligatory arguments. As discussed in the introduction to Chapter 2, Jackendoff (1990; 2002) states that verbs often have more semantic participants than obligatory syntactic arguments and whether an argument is obligatory or not is a syntactic fact which needs to be learned with each verb. Thus, the Semantic therapy was unlikely to aid children's learning in this area. However, the Shape Coding therapy also provided explicit instructions regarding whether arguments are obligatory or not. Hence it was predicted that the children should omit less arguments after this intervention. This was indeed the case, although this was only significant for the *control* verbs and not for the targeted verbs. Therefore, again, associative pairing cannot have been the crucial factor, as this would predict that the children should improve more on targeted than control verbs. Hence, the children must again have learned a more general rule regarding the constructions and number of arguments that are used with particular thematic cores. Indeed, the children had been taught that for verbs denoting a change of location, a prepositional phrase is required (even though it is in fact optional for some verbs). Thus, it seems they must have learned this general rule and applied it to verbs which were not targeted as part of the intervention.

9.5 Conclusions

The study in this chapter showed that both the Semantic and Shape Coding intervention methods were efficacious in improving the production of argument structure in secondary school-aged children with SLI. Children receiving both interventions improved their accuracy in using change of state verbs and those receiving the Shape Coding intervention reduced the number of omitted obligatory arguments. In all cases, progress generalised to untreated verbs.

As a randomised control trial, this study provides strong evidence for the effectiveness of intervention with children with SLI over the age of 10 years. It is also the first controlled study (as far as I am aware) which investigates argument structure therapy with language-impaired children. It involves children with receptive (and expressive) language impairments and thus, although it does not focus directly on comprehension, it is a first step in answering Law et al.'s (2004) call for "further research investigating the effects of intervention for children with receptive language disorders". Consideration of Figure 8.1 in Chapter 8 makes clear that this study is only a small step towards identifying effective methods of intervention for SLI particularly for older children. The literature contains many, many gaps and we owe it to the children to try to fill them. However, intervention studies should be based on detailed assessment and hypotheses regarding the nature of the deficit. Only then can we refine the hypotheses and the intervention in order to ensure intervention is maximally effective. Thus, theory and therapy need to be closely intertwined to enable us to reach the ultimate goal of all research into SLI: to provide each and every individual with SLI with the best possible intervention, thereby enabling them to reach their full potential.

CHAPTER 10 OVERALL CONCLUSIONS

10.1 Summary of findings

The findings of this thesis can be divided into four main areas, which link to the four main results chapters (4, 5, 6 and 9) and are summarised below.

Typical acquisition of argument structure

- Children have more difficulties using and judging change of state verbs than change of location verbs
- Children (and teenagers) have difficulties using the unaccusative construction with verbs which can undergo the causative alternation
- Use of the two constructions associated with the locative and dative alternations varies greatly between individual verbs
- Children and adults show a similar preference for particular constructions for individual verbs which can undergo the dative and locative alternations

Argument structure in children with SLI

- Children with SLI have more difficulties with argument structure than vocabulary or age matched controls, particularly with
    - Change of state verbs
    - Using all obligatory arguments
    - Using the ditransitive construction
- Performance on the argument structure test was most strongly related to measures relying on syntactic abilities
- Performance on the argument structure test was unrelated to performance on the TOPhS non-word repetition test.

Non-word repetition in SLI

- Only half the children with SLI had difficulties repeating the non-words of the TOPhS
- The children with good (SLI-high) versus poor (SLI-low) performance on the TOPhS did not differ in their performance on the TROG, Formulated Sentences or the Argument structure test

- The SLI-low group had more difficulties with marking tense and agreement than the SLI-high group
- Performance on the TOPhS was
  - very highly correlated with performance on the VATT (tense and agreement)
  - independently correlated with metrical complexity and the addition of consonants to form consonant clusters
  - not independently correlated with length as measured by the number of syllables

Therapy for argument structure with secondary school-aged children with SLI

- Both the Semantic and Shape Coding therapies were effective at improving use of the correct construction with change of state verbs and this generalised to control verbs
- Only the Shape Coding therapy led to the use of more obligatory arguments and this generalised to control verbs.

These findings have implications for theories regarding the nature of argument structure and its acquisition by typically developing children and also for theories of the nature of SLI and its identification. They also have practical implications for intervention for children with SLI, both in terms of future intervention research but also in terms of the delivery of services. Each of these areas is discussed below.

10.2 Implications for theories of argument structure

The main implications for theories of argument structure concern the use of verb alternations by the children and adults in Chapter 4. For the causative alternation, the children had particular difficulty using the unaccusative construction, but no difficulties using the transitive construction with alternating verbs. This finding supports those theories which claim that for the majority of verbs undergoing this alternation, the semantic representation which links to the transitive construction is basic and the representation which links to the intransitive (or unaccusative) construction is derived (Jackendoff, 1990; Grimshaw, 1990; Levin & Rappaport Hovav, 1995; Pustejovsky, 1995; Rappaport Hovav & Levin, 1998).

For the locative and dative alternations, adults and children used both constructions involved with the alternations, but their preferences for one construction over the other varied greatly between verbs. This finding is not easily accommodated in current theories of verb alternations and suggests that further experimental work is required which investigates the variability in performance between verbs and between individuals in order to inform further development of theories of argument structure.

10.3 Implications for theories of the acquisition of argument structure

Chapter 4 showed that school-aged children differ from adults in their use of argument structure in several ways, but particularly in their production of change of state verbs and use of the causative alternation. This shows that the use and understanding of argument structure continues to develop during the school years. The theories of argument structure discussed in Chapter 2 assume that children have adult use of argument structure by middle childhood (around 8 years).

The data regarding change of state verbs indicated a developmental pattern whereby the younger children (aged 5 years) use some change of state verbs (incorrectly) purely in the change of location construction (possibly due to a primary reliance on observation and limited use of syntactic bootstrapping), some older children (incorrectly) use these verbs as alternating verbs (possibly because of underspecified semantic representations and hence assignment of the verb to the wrong narrow conflation class) while for others their use is (correctly) restricted only to the change of state construction. These results indicate a developmental progression which merits further investigation, possibly in a longtitudinal study.

The children showed a different pattern of performance to the adults in their use of the causative alternation. Specifically, I hypothesised that they have difficulty using detransitivisation for alternating verbs. The evidence for this hypothesis comes from several sources: they often use transitive sentences for intransitive scenes and omit obligatory (Patient/Theme) objects when the Agent is in the subject position (seeming not to realise that this changes the thematic role of the Subject to Patient/Theme). Also, when they do use detransitivisation, they frequently omit obligatory prepositional phrases.

In contrast to the causative alternation, the children and adults showed a similar pattern of use of the locative and dative alternations. The fact that both groups showed very similar preferences for individual verbs suggests that children may base their preferences on the input they hear from adults.

10.4 Implications for theories of SLI

Theories of SLI need to account for the difficulties the children with SLI (in Chapter 5) showed with argument structure compared to their vocabulary and age controls. Therefore those theories which can only account for morphological difficulties (Gopnik & Crago, 1991; Clahsen et al., 1997; Rice et al., 1995) do not account for the argument structure in this thesis. In Chapters 5-7, I showed that argument structure performance was unrelated to either phonology or phonological short-term memory as measured by the TOPhS non-word repetition test. This provides evidence against those theories of SLI which explain difficulties with argument structure in terms of poor phonological short-term memory (Gathercole & Baddeley, 1990), limited working memory (Leonard, 1998), slow processing speed (Bishop, 1994a), phonological mapping (Chiat, 2001) or temporal processing difficulties (Tallal et al., 1996), as these explanations would predict a relationship between argument structure and non-word repetition.

However, argument structure performance was significantly related to measures involving syntactic abilities such as the TROG and Formulated Sentences. Indeed, the children with SLI differed from their TROG controls on very few measures. This indicates that the ability to use argument structure correctly is related to syntactic abilities. The children with SLI differed from all controls on their use of the ditransitive construction and consistent (incorrect) use of the change of location construction for change of state verbs. Their preference for use of the prepositional phrase construction for the dative alternation resembled the choices of the 3-5 year olds in Osgood and Zehler's (1981) study. Their pattern of errors on the change of state verbs resembled that of the youngest controls in this study (aged 5-6 years). These results suggest that in some areas, the children with SLI show very severely delayed performance.

In section 10.3, I suggested that those controls who consistently used the incorrect construction with change of state verbs, may not be using syntactic bootstrapping in parallel with observation of events in learning the meaning of novel verbs. Therefore, this may also be the case for those children with SLI who make similar errors.

The therapy study in Chapter 9 helped confirm this hypothesis. The children with SLI improved their ability to use the correct construction for change of state verbs (for both targeted and control verbs) with both methods of intervention. I concluded that the Shape Coding therapy might have improved their ability to use syntactic bootstrapping by increasing their awareness of syntactic structures and providing them with information regarding the links between constructions and thematic cores. This would enable them to refine the stored thematic cores for known change of state verbs (including verbs not targeted in therapy). The Semantic therapy was hypothesised to by-pass syntactic bootstrapping and provide the children with direct information regarding the thematic cores of the targeted verbs by focusing on the change of state of the Patient. The unexpected generalisation to control verbs implies that the intervention led the children to notice a similar change of state in semantically related verbs. The success of the Semantic therapy indicates that the children with SLI did indeed have intact abilities to use forward linking as the focus on semantics led to use of the correct construction even though the verbs were not used in sentences during the therapy.

In contrast to the success of both therapy methods in improving use of the correct construction, only the Shape Coding therapy was effective in increasing the use of obligatory arguments. Again, this effect included control verbs and thus the therapy must have enabled the children to learn more general rules rather than merely pairing particular verbs with particular constructions. The therapy method included providing direct instruction and visual prompts regarding the number and type of arguments required with particular thematic cores as well as practice in forming such constructions to match the shape templates. The Semantic therapy focused on the range of participants involved in events, but did not increase the use of obligatory arguments. Therefore, I concluded that the children were already aware of the participants involved but did not know which arguments were obligatory; the Shape Coding therapy helped them learn this.

The main finding of Chapter 6 is that (only) half of the children with SLI had difficulties with repeating the non-words of the TOPhS. Thus, underlying phonological or phonological short-term memory difficulties are not necessary for SLI. Hence, theories of SLI which are based on poor non-word repetition abilities (such as Gathercole & Baddeley, 1990) are not supported by these data. Indeed, all processing theories of SLI would predict that children with SLI should have some difficulties with non-word repetition tasks and thus can only account for the performance of half the children with SLI (the SLI-low group). On the other hand, the linguistic theories of SLI can account for the difficulties shown by the SLI-high group on tense and agreement and could argue that their difficulties with vocabulary and argument structure are an indirect result of this due to the interrelations between different areas of language, especially in development. However, most linguistic theories cannot account for the differences between the two SLI groups on the TOPhS and the effect this appears to have on their vocabulary and ability to mark tense and agreement.

In Chapter 7, I therefore proposed that the children with SLI in this study fell into two groups. Both the SLI-high and SLI-low groups have a syntactic deficit, which may be similar to that proposed in the RDDR hypothesis (van der Lely, 1998) and affects their performance on a wide range of language tests (e.g., TROG, VATT, CELF-3 and Argument Structure) but the SLI-low group have an additional (phonological) deficit which causes poor performance on the TOPhS and has a further detrimental effect on vocabulary, tense and agreement. The model proposed in Chapter 7 is in line with other recent proposals that some children with SLI may be affected by a series of risk factors (Bishop et al., 1999b), or double deficits (Bishop & Snowling, 2004), or even several dissociable deficits (Marshall, 2004; van der Lely, 2005) and that these may be independent, but their effects can interact leading to more severe impairments.

10.5 Implications for intervention with children with SLI

The intervention study in Chapter 9 of this thesis was based on hypotheses formed during the investigations for Part 1. When intervention methods are based on thorough assessment of language abilities and theoretical hypotheses regarding the nature of the children's core difficulties, positive results can be used to validate these hypotheses (see previous section). In addition, even negative results can be informative as they can lead to revision of the hypotheses which in turn can be used to refine the intervention method. In this study, the positive effects appear to be specific to the intervention provided as the children were randomly assigned, assessments carried out 'blind' and equal amounts of attention provided to all groups. Hence the only difference between the groups should be the content of the therapy. The control group made no progress with argument structure in contrast to the two experimental groups who made significant progress. Given the success of both experimental methods, it would now be of value to establish whether children receiving both intervention methods in parallel would make greater gains.

This study showed that even a small amount (4.5 hours) of well-targeted therapy can be effective, even with older children who have received many hours of specialist help in the past. This is therefore strong evidence in favour of continuing to provide intervention for the persisting difficulties of this age group. Unfortunately, many services (in the UK at least) provide very little and often no therapy to children over the age of 11 years. This is perhaps unsurprising given the lack of evidence (discussed in

Chapter 8) that intervention for this age group is effective. However, I hope that the positive results in the study in Chapter 9 will encourage others to investigate the effectiveness of therapy for argument structure in a wider range of age groups and also to investigate therapy for other areas of language in school-aged children.

The predominant philosophy within speech and language therapy services is to provide therapy when the children are as young as possible to prevent future difficulties. While I applaud this principle, I would also argue that at present we have no ‘cure’ for SLI and these children continue to have difficulties throughout childhood and into their adult lives. Therefore, as long as therapy can be shown to be effective, it should continue throughout a child’s school life and possibly beyond. The challenge however, given limited therapy resources, is to establish the core deficits and most effective methods of therapy for every profile of difficulties for each area of language. I hope this thesis has taken us a small step closer towards that goal.

APPENDICES

APPENDIX A: PARTICIPANT DETAILS

	Children with SLI					TROG controls		BPVS controls		Age controls	
SLI-	**CELF-3 (z-scores)**			**Age in**	**BAS (IQ)**	**Age in**	**BAS (IQ)**	**Age in**	**BAS (IQ)**	**Age in**	**BAS (IQ)**
code	**RecL**	**ExpL**	**TotL**	**months**	**z-score**	**months**	**z-score**	**months**	**z-score**	**months**	**z-score**
1-VD	-2.40	-2.40	-2.40	169	-0.05	101	0.50	104	0.40	171	0.05
2-SM	-2.40	-2.40	-2.40	166	1.15	80	1.25	100	1.95	170	1.60
3-SL	-2.33	-2.33	-2.47	132	-0.60	64	0.35	90	0.20	135	-0.10
4-TF	-2.33	-2.40	-2.33	176	-0.25	82	-0.55	103	0.35	176	0.70
5-SL	-1.60	-1.60	-1.80	141	-0.95	119	-0.05	84	-0.20	141	-1.15
6-GD	-2.40	-2.40	-2.40	171	-0.70	120	-0.50	99	-0.55	168	-0.40
7-QR	-2.40	-2.40	-2.33	166	-0.30	96	0.40	111	0.70	168	-0.15
8-HO	-2.40	-2.40	-2.40	166	-0.90	113	-0.60	120	-0.05	164	-0.30
9-BM	-2.07	-1.93	-2.40	155	0.25	115	0.65	115	1.05	152	-0.35
10-MS	-1.60	-1.53	-1.67	136	-0.45	113	0.30	94	0.40	136	0.10
11-OB	-2.33	-2.40	-2.33	179	-0.25	135	-0.10	146	0.40	178	-0.70
12-LJ	-2.07	-1.67	-2.40	149	0.40	77	0.95	104	1.40	146	0.40
13-DS	-1.80	-2.40	-2.40	152	1.55	87	0.85	89	1.10	152	0.70
14-OD	-2.33	-2.33	-2.33	141	-0.85	88	0.35	70	-0.20	142	-0.05
15-RC	-1.60	-2.40	-2.40	157	1.30	94	1.15	136	1.05	158	0.55
Mean	-2.14	-2.20	-2.30	157.07	-0.04	98.93	0.33	104.33	0.53	157.13	0.06
SD	*0.33*	*0.33*	*0.23*	*14.88*	*0.82*	*19.72*	*0.60*	*19.51*	*0.68*	*14.73*	*0.66*
Min	-2.40	-2.40	-2.47	132	-0.95	64	-0.60	70	-0.55	135	-1.15
Max	-1.60	-1.53	-1.67	179	1.55	135	1.25	146	1.95	178	1.60

RecL=Receptive Language, **ExpL**=Expressive Language, **TotL**=Total Language

APPENDIX B: PARTICIPANT SCORES ON STANDARDISED LANGUAGE TESTS

SLI-	TROG raw score				BPVS raw score				Formulated Sentences raw score			
code	SLI	TROG-C	BPVS-C	Age-C	SLI	TROG-C	BPVS-C	Age-C	SLI	TROG-C	BPVS-C	Age-C
1-VD	14	14	15	18	84	70	81	134	16	33	32	37
2-SM	16	16	16	20	92	90	90	133	16	29	34	39
3-SL	9	9	16	17	74	58	71	99	7	young	33	34
4-TF	14	14	15	18	89	70	92	136	15	23	22	43
5-SL	16	16	15	18	75	97	77	149	26	37	19	44
6-GD	17	17	17	19	92	102	94	129	21	38	26	34
7-QR	16	16	16	19	98	91	97	128	24	36	33	42
8-HO	16	16	19	18	110	120	109	107	18	31	38	33
9-BM	17	17	17	20	99	92	96	122	22	30	25	40
10-MS	16	16	19	17	87	101	89	114	29	34	33	43
11-OB	17	17	18	18	110	99	112	115	24	34	39	42
12-LJ	16	16	19	18	92	79	92	112	30	25	36	39
13-DS	17	17	19	18	86	87	86	123	24	31	28	34
14-OD	12	12	15	18	63	69	65	105	5	21	25	41
15-RC	18	18	19	19	115	80	112	122	26	27	43	34
Mean	15.40	15.40	17.00	18.33	91.07	87.00	90.87	121.87	20.20	30.64	31.07	38.60
SD	*2.32*	*2.32*	*1.69*	*0.90*	*14.24*	*16.17*	*13.84*	*13.45*	*7.37*	*5.20*	*6.73*	*3.94*
Min	9	9	15	17	63	58	65	99	5	21	19	33
Max	18	18	19	20	115	120	112	149	30	38	43	44

SLI-	TROG z- score				BPVS z-score				Formulated sentences z-score			
code	SLI	TROG-C	BPVS-C	Age-C	SLI	TROG-C	BPVS-C	Age-C	SLI	TROG-C	BPVS-C	Age-C
1-VD	-1.93	-0.87	-0.60	-0.13	-2.53	-0.93	-0.33	1.20	-2.33	0.33	0.00	-0.33
2-SM	-1.20	0.67	-0.33	2.13	-1.60	1.47	0.27	0.93	-2.33	0.33	0.33	0.00
3-SL	-2.47	-0.73	0.27	-0.53	-1.87	0.27	-0.33	-0.53	-2.33	young	1.00	-0.33
4-TF	-1.93	-0.07	-0.60	-0.13	-2.53	0.00	0.27	1.00	-2.33	0.33	-1.00	1.33
5-SL	-0.93	-0.53	-0.07	0.00	-2.07	0.07	0.33	3.40	-1.33	-0.67	-1.00	2.00
6-GD	-0.73	-0.40	0.20	0.73	-2.20	0.27	0.53	0.53	-2.33	0.33	-0.67	-0.67
7-QR	-1.20	-0.27	-0.53	0.73	-1.67	0.53	0.27	0.40	-2.33	0.67	-0.33	1.00
8-HO	-1.20	-0.53	0.93	-0.13	-1.00	1.60	0.73	-1.00	-2.33	-0.67	0.33	-1.00
9-BM	-0.73	0.00	0.00	2.13	-1.33	-0.13	0.20	0.60	-2.33	-0.67	-1.00	0.67
10-MS	-0.93	-0.53	2.20	-0.53	-1.27	0.47	0.53	0.53	-1.33	0.00	1.00	1.33
11-OB	-0.73	-0.53	-0.13	-0.13	-1.53	-0.53	0.00	-1.00	-2.33	-0.33	0.33	1.00
12-LJ	-1.20	0.67	1.47	-0.13	-1.20	1.00	0.27	0.00	-1.33	0.67	0.67	0.33
13-DS	-0.73	0.73	2.20	-0.13	-1.73	1.00	0.73	0.67	-2.33	0.67	0.00	-0.67
14-OD	-2.07	-0.93	1.13	0.00	-2.53	-0.33	0.40	-0.33	-2.33	-0.67	young	1.00
15-RC	-0.13	0.73	0.80	0.73	-0.33	-0.20	0.40	0.33	-2.33	-0.67	1.33	-0.67
Mean	-1.21	-0.17	0.46	0.31	-1.69	0.30	0.28	0.45	-2.13	-0.03	0.07	0.33
SD	*0.63*	*0.60*	*0.95*	*0.84*	*0.62*	*0.72*	*0.32*	*1.06*	*0.41*	*0.56*	*0.79*	*0.93*
Min	-2.47	-0.93	-0.60	-0.53	-2.53	-0.93	-0.33	-1.00	-2.33	-0.67	-1.00	-1.00
Max	-0.13	0.73	2.20	2.13	-0.33	1.60	0.73	3.40	-1.33	0.67	1.33	2.00

T-C = TROG control, **B-C** = BPVS control, **A-C** = Age control, **young** = too young for age range of test

APPENDIX C: PRODUCTION TEST

Verb	Brown et al. verbal frequency	Verb Scene with target sentence	Num oblig args	Alternative target sentence	Num oblig args
		the water is bubbling (in the pan)	1		
bubbling	n/a	(the girl is making) the orange (is) juice bubble/ing	1		
		the soup is bubbling (in the pan)	1		
		the man is building a car	2		
building	4	the girl is building a house (out of lego)	1		
		the girl is building a tower (out of bricks)	2		
		the lady is covering her hair (with a scarf)	2		
covering	9	a cloth is covering the table	2		
		the lady is covering the bread (with chocolate spread)	2		
		the sink is emptying (of water)	1	the water is emptying out of the sink	2
emptying	6	the lady is emptying a jug (of water)	2	the lady is emptying the water out of the jug	3
		the lady is emptying the jar (of sweets)	2	the lady is emptying some sweets out of a jar	3
		the is lady falling (over)	1		
falling	7	the pen is falling (off a table onto the floor)	1		
		the paper is falling (from the lady's hand)	1		
		the lady is filling a jar (with sweets)	2		
filling	7	the girl is filling a cup (with orange juice)	2		
		the sink is filling (with water)	1	the water is filling the sink	2
		the man is giving some rubbish to a lady	3	the man is giving the lady some rubbish	3
giving	102	the girl is giving food to her doll	3	the girl is giving her doll some food	3
		the man is giving a present to the girl	3	the man is giving the girl a present	3
		the girl is hanging from a climbing frame	2		
hanging	8	the shirt is hanging on a washing line	2		
		the lady is hanging her coat on the door	3		

Continued on next page

Verb	Brown et al. Verbal frequency	Verb Scene with target sentence	Num oblig args	Alternative target sentence	Num oblig args
		(a girl is making) a frog (is) jump(ing)	1		
jumping	n/a	the girl is jumping	1		
		the girl is jumping (over a box)	1		
		the girl is laughing (at a book)	1		
laughing	6	(the man is making) a lady (is) laugh(ing) (by tickling her)	1		
		(the man is making) a lady (is) laugh(ing) (by pulling faces)	1		
		the candle / wax is melting	1	the flame is melting the candle/wax	2
melting	2	the man is melting the chocolate	2		
		the butter is melting	1		
		the girl is opening a box	2		
opening	28	a door is opening	1		
		the lady is opening the door	2		
		the girl is packing (her books into her school bag)	1	girl packing (her school bag with books)	1
packing	2	the man is packing his clothes into a suitcase	1	the man is packing (his suitcase)	1
		the girl is packing (jumpers into a bag)	1	the is girl packing (a bag with jumpers)	1
		the lady is passing a biscuit (to a man)	2	the lady is passing a man a biscuit	3
passing	13	the man is passing some cake (to the lady)	2	the man is passing a lady a piece of cake	3
		the lady is passing some bread (to a man)	2	the lady is passing the man some bread	3
		the lady is peeling an apple	2	the lady is peeling the skin off an apple	3
peeling	n/a	the man is peeling a banana	2	the man is peeling the skin off a banana	3
		the wall is peeling	1	the paint is peeling off a wall	2
		the water is pouring down the steps	2		
pouring	2	the girl is pouring orange juice into a glass	3		
		the lady is pouring the sweets onto the table	3		

Continued on next page

Verb	Brown et al. Verbal frequency	Verb Scene with target sentence	Num oblig args	Alternative target sentence	Num oblig args
		the lady is putting an apple in the bowl	3		
putting	158	the lady is putting vase on the table	3		
		the girl is putting some books in her bag	3		
		the man is robbing a lady (of her mobile phone)	2		
robbing	n/a	the man is robbing a lady (of her necklace)	2		
		the man is robbing a lady (of her handbag)	2		
		the lady is rolling off the bed	2		
rolling	n/a	the man is rolling a ball (along the floor)	2		
		the pencil is rolling (down a piece of wood)	2		
		the lady is sewing	1	the lady is sewing a button onto a cardigan	3
sewing	2	the lady is sewing	1		
		the lady is sewing (a skirt)	1		
		the water is spilling out of a bucket	2		
spilling	1	the lady is spilling water (onto the surface)	2		
		the lady is spilling rice krispies (onto the surface)	2		
		the man is spreading butter (on his toast)	2	the man is spreading his toast	2
spreading	11	the milk is spreading over the surface	2		
		the lady is spreading chocolate spread (on the bread)	2	the lady is spreading her bread (with chocolate spread)	2
		the lady is stealing a camera from a man	1		
stealing	2	the man is stealing a necklace from a lady	1		
		the man is stealing a lady's purse	1		
		the lady is wiping her feet (on the door mat)	2		
wiping	n/a	the man is wiping his face (with a cloth)	2	the man is wiping the water off his face	3
		the man is wiping the table (with a cloth)	2	the man is wiping something off the table (with a cloth)	3

APPENDIX D: INDIVIDUAL SCORES ON THE TOPHS

TOPHS GROUP	SLI-code	SLI score	TROG control	BPVS control	Age control
SLI-LOW TOPhS GROUP and their individual controls	2-SM	32	87	92	88
	14-OD	32	76	72	87
	6-GD	34	88	80	93
	4-TF	40	81	84	96
	9-BM	41	82	78	86
	1-VD	45	82	93	82
	10-MS	47	94	77	92
	Mean	38.7	84.3	82.3	89.1
	SD	*6.2*	*5.9*	*7.8*	*4.8*
	Min	32	76	72	82
	Max	47	94	93	96
SLI-HIGH TOPhS GROUP and their individual controls	3-SLO	68	66	79	88
	12-LJ	70	77	64	95
	7-QR	71	88	95	87
	13-DS	75	93	86	88
	5-SLU	84	61	84	89
	8-HO	89	83	95	64
	11-OB	89	88	95	82
	15-RC	89	80	89	88
	Mean	79.4	79.5	85.9	85.1
	SD	*9.3*	*11.1*	*10.6*	*9.2*
	Min	68	61	64	64
	Max	89	93	95	95
COMBINED GROUPS	Mean	60.4	81.7	84.2	87.0
	SD	*22.4*	*9.1*	*9.3*	*7.5*
	Min	32	61	64	64
	Max	89	94	95	96

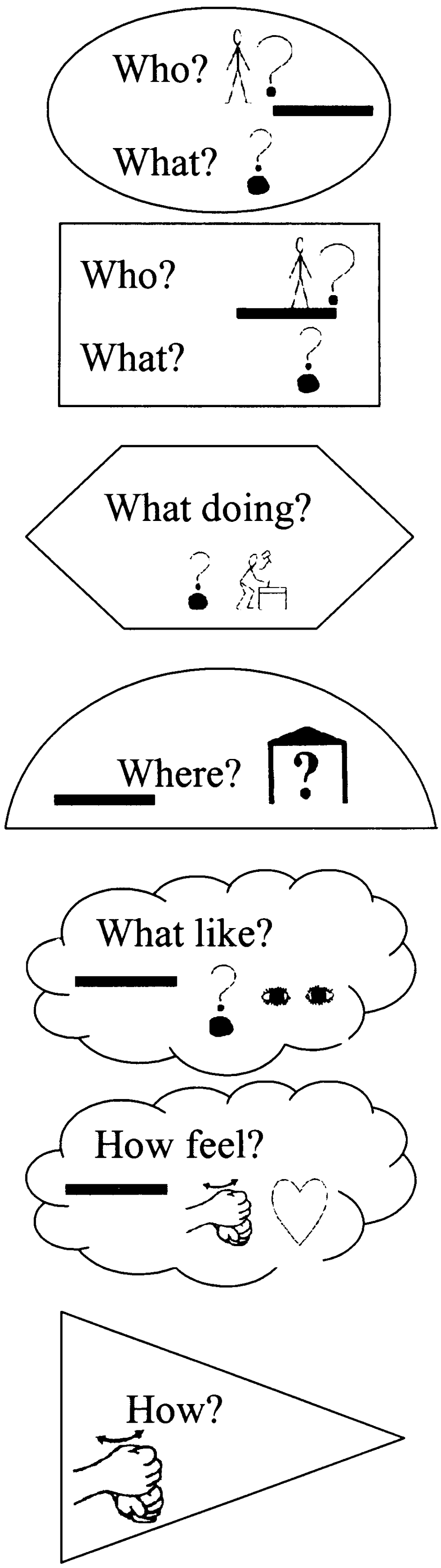
APPENDIX E: INDIVIDUAL LANGUAGE SCORES BY THERAPY GROUP

				CELF-3 z-scores			BPVS		TROG	
	SLI - Code	Age at Test 1	Performance IQ	Receptive	Expressive	Total	BPVS raw score	BPVS z-score	TROG raw score	TROG z-score
SEMANTIC THERAPY	OD	12;9	-0.30	-2.40	-2.40	-2.40	76	-2.27	12	-2.07
	SLU	13;2	-0.95	-2.40	-2.40	-2.40	92	-1.60	16	-0.93
	HO	15;2	-0.90	-2.40	-2.40	-2.40	111	-1.33	16	-1.20
	WC	12;11	0.75	-1.80	-2.40	-2.40	97	-1.27	15	-1.60
	RA	12;6	-1.45	-2.40	-2.40	-2.47	96	-1.13	13	-2.20
	GD	15;8	-0.70	-2.40	-2.40	-2.40	119	-0.80	17	-0.73
	BM	14;4	0.25	-2.07	-1.93	-2.40	106	-1.33	17	-0.73
	YL	12;2	-0.70	-1.80	-2.40	-2.40	90	-1.33	16	-1.20
	CM	12;10	-1.10	-2.33	-2.33	-2.47	94	-1.40	17	-1.93
	Mean	**13;6**	**-0.57**	**-2.22**	**-2.34**	**-2.41**	**98**	**-1.39**	**15**	**-1.40**
	SD	***1;3***	***0.69***	***0.26***	***0.15***	***0.03***	***13***	***0.40***	***2***	***0.57***
	Min	**12;2**	**-1.45**	**-2.40**	**-2.40**	**-2.47**	**76**	**-2.27**	**12**	**-2.20**
	Max	**15;8**	**0.75**	**-1.80**	**-1.93**	**-2.40**	**119**	**-0.80**	**17**	**-0.73**
SHAPE CODING THERAPY	TF	16;1	-0.25	-2.33	-2.40	-2.33	98	-2.27	14	-1.93
	QR	15;3	-0.30	-1.13	-1.33	-2.33	100	-2.00	17	-0.73
	SLO	12;5	-0.60	-2.40	-2.40	-2.47	66	-2.60	9	-2.47
	SK	13;2	-1.40	-2.40	-2.40	-2.40	98	-1.33	14	-1.93
	DS	13;11	1.55	-2.07	-1.93	-2.40	98	-1.67	17	-0.73
	MN	11;8	-0.50	-2.40	-2.33	-2.33	75	-1.93	11	-2.27
	SM	14;3	1.15	-2.40	-2.40	-2.40	80	-2.73	16	-1.20
	LJ	13;8	0.40	-1.80	-1.67	-2.40	106	-0.93	16	-1.20
	TG	14;8	-1.30	-2.40	-2.40	-2.40	85	-2.53	8	-3.00
	Mean	**13;10**	**-0.14**	**-2.15**	**-2.14**	**-2.39**	**90**	**-2.00**	**14**	**-1.72**
	SD	***1;4***	***1.01***	***0.43***	***0.40***	***0.04***	***14***	***0.61***	***3***	***0.80***
	Min	**11;8**	**-1.40**	**-2.40**	**-2.40**	**-2.47**	**66**	**-2.73**	**8**	**-3.00**
	Max	**16;1**	**1.55**	**-1.13**	**-1.33**	**-2.33**	**106**	**-0.93**	**17**	**-0.73**
CONTROL THERAPY	KJ	12;6	-0.70	-2.07	-2.40	-2.40	89	-1.60	14	-1.93
	HL	14;5	-0.25	-2.33	-1.53	-2.00	106	-1.33	18	-0.13
	OC	12;4	-1.20	-1.80	-2.40	-2.40	102	-0.80	17	-0.73
	GW	11;2	-1.05	-1.40	-2.33	-2.33	92	-0.80	12	-2.07
	GS	12;3	-0.85	-2.40	-2.40	-2.40	102	-0.67	11	-2.27
	LC	11;5	0.45	-2.33	-2.33	-2.33	78	-1.67	12	-2.07
	ST	13;5	-1.30	-2.40	-2.40	-2.40	103	-1.13	15	-1.60
	LN	14;6	-1.30	-2.40	-1.67	-2.40	118	-0.60	16	-1.13
	HK	13;3	0.15	-2.07	-2.40	-2.40	105	-1.00	16	-1.20
	Mean	**12;9**	**-0.67**	**-2.13**	**-2.21**	**-2.34**	**99**	**-1.07**	**15**	**-1.46**
	SD	***1;3***	***0.65***	***0.34***	***0.35***	***0.13***	***12***	***0.39***	***2***	***0.72***
	Min	**11;0**	**-1.30**	**-2.40**	**-2.40**	**-2.40**	**78**	**-1.67**	**11**	**-2.27**
	Max	**14;6**	**0.45**	**-1.40**	**-1.53**	**-2.00**	**118**	**-0.60**	**18**	**-0.13**
COMBINED	**Mean**	**13;3**	**-0.46**	**-2.17**	**-2.23**	**-2.38**	**96**	**-1.48**	**15**	**-1.53**
	SD	***1;4***	***0.80***	***0.34***	***0.32***	***0.08***	***13***	***0.60***	***3***	***0.69***
	Min	**11;0**	**-1.45**	**-2.40**	**-2.40**	**-2.47**	**66**	**-2.73**	**8**	**-3.00**
	Max	**16;1**	**1.55**	**-1.13**	**-1.33**	**-2.00**	**119**	**-0.60**	**18**	**-0.13**

APPENDIX F: VIDEO SCENES

Verb		Scene 1	Scene 2	Scene 3
Change of State verbs	cover	lady covering her head with a scarf	man covering his dinner with gravy	lady covering bread with chocolate spread
	fill	lady filling a jar with sweets	girl filling a glass with juice	lady filling a bag with clothes
	block	the man is blocking the doorway with stools	man blocking a watering can with bluetack	man blocking a road with a brick
	surround	girl surrounding animals with fence	man surrounding a table with chairs	girl surrounding a bus with blocks
	build	girl building a stable with lego	girl building a tower with bricks	girl building a wall with bricks
	decorate	girl decorating a card with patterns	girl decorating biscuits with icing	man decorating a tree with tinsel
Change of Location verbs	spill	lady spilling water on the surface	lady spilling cereal on the surface	man spilling drink on the grass
	pour	lady pouring water out of a jug into sink	lady pouring sweets out of a jar onto a table	girl pouring juice into a glass out of jug
	hang	lady hanging coat on hook	man hanging T shirt on washing line	lady hanging coat over chair
	lean	man leaning ladder against the wall	man leaning broom against table	lady leaning pencil against mug
	put	girl putting a book in her bag	man putting clothes in case	lady putting apple in bowl
	place	lady placing vase on table	lady placing apple in bowl	lady placing lid on pan
Alternating verbs	empty	lady emptying jug of water into sink	lady emptying sweets out of jar onto table	man emptying glass of ribena (by drinking)
	clear	lady clearing table of cups	lady clearing table of books	man clearing leaves off patio
	sweep	lady sweeping floor	man sweeping leaves off the patio	man sweeping cereal off floor into dustpan
	wipe	man wiping table with cloth	lady wiping shoes on mat	man wiping face with flannel
	wrap	man wrapping present	lady wrapping mug in tissue paper	lady wrapping cling film around a sandwich
	stuff	man stuffing a chicken	lady stuffing clothes into a bag	lady stuffing clothes into a basket

APPENDIX G: SHAPES, COLOURS, QUESTIONS AND SYMBOLS FOR SHAPE CODING THERAPY



Colour	*Shape*
Red = noun	*Oval = Noun Phrase (external argument)*
Red = noun	*Rectangle = Noun Phrase (internal argument)*
Yellow = verb	*Hexagon = Verb Phrase*
Blue = Preposition	*Hexagon = Prepositional Phrase*
Green = Adjective	*Cloud = Adjective Phrase*
No colour	*Variety of phrases:* *1.* with + *NP* *2.* by *plus progressive verb* *3. adverbial phrase*

APPENDIX H: INDIVIDUAL SCORES FOR ARGUMENT STRUCTURE PRODUCTION

THERAPY GROUP	SLI-code	TEST 1 pre-therapy	TEST 2 post-therapy	TEST 3 follow-up	TEST 4 N/A
SEMANTICS THERAPY PHASE 1	OD	0.57	0.65	0.74	
	RA	0.76	0.94	0.83	
	SLU	0.87	0.85	0.96	
	WC	0.87	0.83	0.94	
	HO	0.94	0.96	0.98	
	Mean	0.80	0.85	0.89	
	SD	*0.14*	*0.12*	*0.10*	
	Min	0.57	0.65	0.74	
	Max	0.94	0.96	0.98	
SHAPE CODING THERAPY PHASE 1	SLO	0.55	0.57	0.41	
	DS	0.74	0.83	0.85	
	TF	0.76	0.93	0.93	
	SK	0.76	0.83	0.80	
	QR	0.89	0.96	0.98	
	Mean	0.74	0.82	0.79	
	SD	*0.12*	*0.15*	*0.23*	
	Min	0.55	0.57	0.41	
	Max	0.89	0.96	0.98	
CONTROL THERAPY PHASE 1	KJ	0.76	0.85	0.81	
	GW	0.87	0.59	0.79	
	GS	0.87	0.85	0.81	
	OC	0.92	0.93	0.87	
	HL	0.93	0.96	0.89	
	Mean	0.87	0.84	0.83	
	SD	*0.07*	*0.15*	*0.04*	
	Min	0.76	0.59	0.79	
	Max	0.93	0.96	0.89	
		baseline	pre-therapy	post-therapy	follow-up
SEMANTICS THERAPY PHASE 2	YL	0.83	0.80	0.87	0.74
	GD	0.80	0.83	0.91	0.87
	CM	0.76	0.83	0.89	0.93
	BM	0.81	0.89	0.89	0.96
	Mean	0.80	0.84	0.89	0.88
	SD	*0.03*	*0.04*	*0.02*	*0.10*
	Min	0.76	0.80	0.87	0.74
	Max	0.83	0.89	0.91	0.96
SHAPE CODING THERAPY PHASE 2	TG	0.48	0.26	0.67	0.56
	MN	0.87	0.89	0.92	0.93
	SM	0.93	0.89	0.93	0.83
	LJ	0.98	0.96	1.00	1.00
	Mean	0.82	0.75	0.88	0.83
	SD	*0.23*	*0.33*	*0.14*	*0.19*
	Min	0.48	0.26	0.67	0.56
	Max	0.98	0.96	1.00	1.00
CONTROL THERAPY PHASE 2	LC	0.54	0.69	0.72	0.69
	ST	0.83	0.85	0.65	0.80
	LN	0.91	0.93	0.94	0.94
	HK	0.91	0.96	1.00	0.94
	Mean	0.80	0.86	0.83	0.84
	SD	*0.18*	*0.12*	*0.17*	*0.12*
	Min	0.54	0.69	0.65	0.69
	Max	0.98	0.96	1.00	1.00

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